THE

AMERICAN

JOURNAL OF SCIENCE AND ARTS.

[THIRD SERIES.]

ART. XLII.—*Introduction and Succession of Vertebrate Life in America;* by O. C. MARSH.

[Address before the American Association for the Advancement of Science, at Nashville, Tenn., August 30, 1877.]

THE origin of life, and the order of succession in which its various forms have appeared upon the earth, offer to science its most inviting and most difficult field of research. Although the primal origin of life is unknown, and may perhaps never be known, yet no one has a right to say how much of the mystery now surrounding it science cannot remove. It is certainly within the domain of science to determine when the earth was first fitted to receive life, and in what form the earliest life began. To trace that life in its manifold changes through past ages to the present is a more difficult task, but one from which modern science does not shrink. In this wide field, every earnest effort will meet some degree of success; every year will add new and important facts; and every generation will bring to light some law, in accordance with which ancient life has been changed into life as we see it around us to-day. That such a development has taken place, no one will doubt who has carefully traced any single group of animals through its past history, as recorded in the crust of the earth. The evidence will be especially conclusive, if the group selected belongs to the higher forms of life, which are sensitive to every change in their surroundings. But I am sure I need offer here no argument for evolution; since to doubt

evolution to-day is to doubt science, and science is only another name for truth.

Taking, then, evolution as a key to the mysteries of past life on the earth, I invite your attention to the subject I have chosen: THE INTRODUCTION AND SUCCESSION OF VERTEBRATE LIFE IN AMERICA.

In the brief hour allotted to me, I could hardly hope to give more than a very incomplete sketch of what is now known on this subject. I shall, therefore, pass rapidly over the lower groups, and speak more particularly of the higher vertebrates, which have an especial interest to us all, in so far as they approach man in structure, and thus indicate his probable origin. These higher vertebrates, moreover, are most important witnesses of the past, since their superior organization made them ready victims to slight climatic changes, which would otherwise have remained unrecorded.

In considering the ancient life of America, it is important to bear in mind that I can only offer you a brief record of a few of the countless forms that once occupied this continent. The review I can bring before you will not be like that of a great army, when regiment after regiment with full ranks moves by in orderly succession, until the entire host has passed. My review must be more like the roll-call after a battle, when only a few scarred and crippled veterans remain to answer to their names. Or rather, it must resemble an array of relics, dug from the field of some old Trojan combat, long after the contest, when no survivor remains to tell the tale of the strife. From such an ancient battle-field, a Schliemann might unearth together the bronze shield, lance-head, and gilded helmet of a prehistoric leader, and learn from them with certainty his race and rank. Perhaps the skull might still retain the barbaric stone weapon by which his northern foe had slain him. Near by, the explorer might bring to light the commingled coat of mail and trappings of a horse and rider, so strangely different from the equipment of the chief, as to suggest a foreign ally. From these, and from the more common implements of war that fill the soil, the antiquary could determine, by patient study, what nations fought, and, perhaps, when, and why.

By this same method of research, the more ancient strata of the earth have been explored, and, in our Western wilds, veritable battle-fields, strown with the fossil skeletons of the slain, and guarded faithfully by savage superstition, have been despoiled, yielding to science treasures more rare than bronze or gold. Without such spoils, from many fields, I could not have chosen the present theme for my address to-night.

According to present knowledge, no vertebrate life is known to have existed on this continent in the Archæan, Cambrian, or Silurian periods; yet during this time, more than half of the thickness of American stratified rocks was deposited. It by no means follows that vertebrate animals of some kind did not exist here in those remote ages. Fishes are known from the Upper Silurian of Europe, and there is every probability that they will yet be discovered in our strata of the same age, if not at a still lower horizon.

In the shore deposits of the early Devonian sea, known as the Schoharie Grit, characteristic remains of Fishes were preserved, and in the deeper sea that followed, in which the Corniferous limestone was laid down, this class was well represented. During the remainder of the Devonian, Fishes continue abundant in the shallower seas, and, so far as now known, were the only type of vertebrate life. These fishes were mainly Ganoids, a group, represented in our present waters by the Gar-pike (*Lepidosteus*) and Sturgeon (*Acipenser*), but, in the Devonian sea, chiefly by the Placoderms, the exact affinities of which are somewhat in doubt. With these were Elasmobranchs, or the Shark tribe, and among them a few Chimæroids, a peculiar type, of which one or two members still survive. The Placoderms were the monarchs of the ocean. All were well protected by a massive coat of armor, and some of them attained huge dimensions. The American Devonian fishes now known are not as numerous as those of Europe, but they were larger in size, and mostly inhabitants of the open sea. Some twenty genera and forty species have been described.

The more important genera of Placoderms are, *Dinichthys*, *Aspidichthys*, and *Diplognathus*, our largest Palæozoic fishes. Others are, *Acanthaspis*, *Acantholepis*, *Coccosteus*, *Macropetalichthys*, and *Onychodus*. Among the Elasmobranchs were, *Cladodus*, *Ctenacanthus*, *Machæracanthus*, *Rhynchodus*, and *Ptyctodus*, the last two being regarded as Chimæroids. In the Chemung epoch, the great Dipterian family was introduced with *Dipterus*, *Heliodus*, and possibly *Ceratodus*. Species of the European genera, *Bothriolepis* and *Holoptychius*, have likewise been found in our Devonian deposits.

With the close of the Devonian, came the almost total extinction of the great group of Placoderms, while the Elasmobranchs, which had hitherto occupied a subordinate position, increase in numbers and size, and appear to be represented by Sharks, Rays, and Chimæras. Among the members of this group from the Carboniferous, were numerous Cestracionts, species of *Cochliodus* of large size, with others of the genera *Deltodus*, *Helodus*, *Psammodus* and *Sandalodus*. Of the Petalodonts, there were *Antliodus*, *Chomatodus*, *Ctenoptychius*, *Petalodus* and

Petalorhynchus; and of the Hybodonts, the genera *Cladodus*, *Carcharopsis* and *Diplodus*. These Elasmobranchs were the rulers of the Carboniferous open sea, and more than one hundred species have been found in the lower part of this formation alone. The Ganoids, although still abundant, were of smaller size, and denizens of the more shallow and confined waters. The latter group of fishes was represented by true Lepidostidæ, of the genera *Palœoniscus*, *Amblypterus*, *Platysomus* and *Eurylepis*. Other genera are, *Rhizodus*, *Megalichthys*, *Ctenodus*, *Edestus*, *Orodus*, *Ctenacanthus*, *Gyracanthus*, and *Cœlacanthus*. Most of these genera occur also in Europe.

From the Permian rocks of America, no vertebrate remains are known, although in the same formation of Europe Ganoids are abundant; and with them are remains of Sharks, and some other fishes, the affinities of which are doubtful. The Palæozoic fishes at present known from this country are quite as numerous as those found in Europe.

In the Mesozoic age, the Fishes of America begin to show a decided approach to those of our present waters. From the Triassic rocks, Ganoids only are known, and they are all more or less closely related to the modern Gar-pike, or *Lepidosteus*. They are of small size, and the number of individuals preserved is very large. The characteristic genera are, *Catopterus*, *Ischypterus*, *Ptycholepis*, *Rhabdolepis*, and *Turseodus*. From the Jurassic deposits, no remains of fishes are known, but in the Cretaceous, ichthyic life assumed many and various forms; and the first representatives of the Teleosts, or bony fishes, the characteristic fishes of to-day, make their appearance. In the deep open sea of this age, Elasmobranchs were the prevailing forms, Sharks and Chimæroids being most numerous. In the great inland Cretaceous sea of North America, true osseous fishes were most abundant, and among them were some of carnivorous habits, and immense size. The more sheltered bays and rivers were shared by the Ganoids and Teleosts, as their remains testify. The more common genera of Cretaceous Elasmobranchs were, *Otodus*, *Oxyrhina*, *Galeocerdo*, *Lamna* and *Ptychodus*. Among the osseous fishes, *Beryx*, *Enchodus*, *Portheus* and *Saurocephalus* were especially common, while the most important genus of Ganoids was *Lepidotus*.

The Tertiary fishes are nearly all of modern types, and from the beginning of this period there was comparatively little change. In the marine beds, Sharks, Rays and Chimæroids maintained their supremacy, although Teleosts were abundant, and many of them of large size. The Ganoids were comparatively few in number. In the earliest Eocene fresh-water deposits, it is interesting to find that the modern Gar-pike,

and *Amia*, the Dog-fish of our western lakes, which by their structure are seen to be remnants of a very early type, are well represented by species so closely allied to them that only an anatomist could separate the ancient from the modern. In the succeeding beds, these fishes are still abundant, and with them are Siluroids nearly related to the modern Cat-fish (*Pimelodus*). Many small fishes, allied apparently to the modern herring (*Clupea*), left their remains in great numbers in the same deposits, and, with them has been recently found a land-locked Ray (*Heliobatis*).

The almost total absence of remains of fishes from the Miocene lake-basins of the West is a remarkable fact, and perhaps may best be explained by the theory that these inland waters, like many of the smaller lakes in the same region to-day, were so impregnated with mineral matters as to render the existence of vertebrate life in them impossible. No one who has tasted such waters, or has attempted to ford one of the modern alkaline lakes which are often met with on the present surface of the same deposits, will doubt the efficiency of this cause, or the easy entombment of the higher vertebrates that ventured within their borders. In the Pliocene lake-basins of the same region, remains of fishes were not uncommon, and in some of them are very numerous. These are all of modern types, and most of them are Cyprinoids, related to the modern Carp. The Post-pliocene fishes are essentially those of to-day.

In this brief synopsis of the past ichthyic life of this Continent, I have mentioned only a few of the more important facts, but sufficient, I trust, to give an outline of its history. Of this history, it is evident that we have as yet only a very imperfect record. We have seen that the earliest remains of fishes known in this country, are from the lower Devonian; but these old fishes show so great a diversity of form and structure, as to clearly indicate for the class a much earlier origin. In this connection, we must bear in mind that the two lowest groups of existing fishes are entirely without osseous skeletons, and hence, however abundant, would leave no permanent record in the deposits in which remains of fishes are usually preserved. It is safe to infer, from the knowledge which we now possess of the simpler forms of life, that even more of the early fishes were cartilaginous, or so destitute of hard parts as to leave no enduring traces of their existence. Without positive knowledge of such forms, and considering the great diversity of those we have, it would seem a hopeless task at present to attempt to trace successfully the genealogy of this class. One line, however, appears to be direct, from our modern Gar-pike, through the lower Eocene *Lepidosteus* to the *Lepidotus* of the Cretaceous, and perhaps on through the Triassic *Ischypterus*

and Carboniferous *Palæoniscus;* but beyond this, in our rocks, it is lost. The living Chimæra of our Pacific coast has nearly allied forms in the Tertiary and Cretaceous, more distant relatives in the Carboniferous, and a possible ancestor in the Devonian *Rhynchodus.* Our Sharks likewise can be traced with some certainty back to the Palæozoic; and even the *Lepidosiren*, of South America, although its immediate predecessors are unknown, has some peculiar characters which strongly point to a Devonian ancestry. These suggestive lines indicate a rich field for investigation in the ancient life-history of American fishes.

The Amphibians, the next higher class of vertebrates, are so closely related to the fishes in structure, that some peculiar forms of the latter have been considered by anatomists as belonging to this group. The earliest evidence of Amphibian existence, on this continent, is in the Sub-Carboniferous, where foot-prints have been found which were probably made by Labyrinthodonts, the most ancient representatives of the class. Well preserved remains are abundant in the Coal Measures, and show that the Labyrinthodonts differed in important particulars from all modern Amphibians, the group which includes our frogs and salamanders. Some of these ancient animals resembled a salamander in shape, while others were serpent-like in form. None of those yet discovered were frog-like, or without a tail, although the restored Labyrinthodont of the text books is thus represented. All were protected by large pectoral bony plates, and an armor of small scutes on the ventral surface of the body. The walls of their teeth were more or less folded, whence the name Labyrinthodont. The American Amphibians known from osseous remains are all of moderate size, but the foot-prints attributed to this group indicate animals larger than any of the class yet found in the old world. The Carboniferous Amphibians were abundant in the swampy tropical forests of that period, and their remains have been found imbedded in the coal then deposited, as well as in hollow stumps of the trees left standing.

The principal genera of this group from American Carboniferous rocks, are, *Sauropus*, known only from footprints, *Baphetes*, *Dendrerpeton*, *Hylonomus*, *Hylerpeton*, *Raniceps*, *Pelion*, *Leptophractus*, *Molgophis*, *Ptyonius*, *Amphibamus*, *Cocytinus*, and *Ceraterpeton.* The last genus occurs also in Europe. Certain of these genera have been considered by some writers to be more nearly related to the Lizards, among true reptiles. Some other genera known from fragmentary remains or footprints in this formation have likewise been referred to the true reptiles, but this question can perhaps be settled only by future discoveries.

No Amphibia are known from American Permian strata, but

in the Triassic, a few characteristic remains have been found. The three genera, *Dictyocephalus*, *Dispelor* and *Pariostegus*, have been described, but, although apparently all Labyrinthodonts, the remains preserved are not sufficient to add much to our knowledge of the group. The Triassic foot-prints which have been attributed to Amphibians are still more unsatisfactory, and at present no important conclusions in regard to this class can be based upon them. From the Jurassic and Cretaceous beds of this Continent, no remains of Amphibians are known. A few only have been found in the Tertiary, and these are all of modern types.

The Amphibia are so nearly allied to the Ganoid fishes, that we can hardly doubt their descent from some member of that group. With our present limited knowledge of the extinct forms, however, it would be unprofitable to attempt to trace in detail their probable genealogy.

The authors to whom especial credit is due for our knowledge of American fossil Fishes and Amphibians, are Newberry, Leidy, Cope, Dawson, Agassiz, St. John, Gibbes, Wyman, Redfield, and Emmons, and the principal literature of the subject will be found in their publications.

Reptiles and Birds form the next great division of vertebrates, the Sauropsida, and of these the Reptiles are the older type, and may be first considered. While it may be stated with certainty that there is at present no evidence of the existence of this group in American rocks older than the Carboniferous, there is some doubt in regard to their appearance even in this period. Various foot-prints which strongly resemble those made by Lizards; a few well preserved remains similar to the corresponding bones in that group; and a few characteristic specimens, nearly identical with those from another order of this class, are known from American Coal Measures. These facts, and some others which point in the same direction, render it probable that we may soon have conclusive evidence of the presence of true Reptiles in this formation, and in our overlying Permian, which is essentially a part of the same series. In the Permian rocks of Europe, true Reptiles have been found.

The Mesozoic Period has been called the Age of Reptiles, and during its continuance some of the strangest forms of reptilian life made their appearance, and became extinct. Near its commencement, while the Triassic shales and sandstones were being deposited, true reptiles were abundant. Among the most characteristic remains discovered are those of the genus *Belodon*, which is well known also in the Trias of Europe. It belongs to the Thecodont division of Reptiles, which have teeth in distinct sockets, and its nearest affinities

are with the Crocodilia, of which order it may be considered the oldest known representative. In the same strata in which the Belodonts occur, remains of Dinosaurs are found, and it is a most interesting fact that these highest of reptiles should make their appearance, even in a generalized form, at this stage of the earth's history. The Dinosaurs, although true reptiles in all their more important characters, show certain well marked points of resemblance to existing birds of the order *Ratitæ*, a group which includes the Ostriches; and it is not improbable that they were the parent stock from which birds originated.

During Triassic time, the Dinosaurs attained in America an enormous development both in variety of forms and in size. Although comparatively few of their bones have as yet been discovered in the rocks of this country, they have left unmistakable evidence of their presence in the foot-prints and other impressions upon the shores of the waters which they frequented. The Triassic sandstone of the Connecticut Valley has long been famous for its fossil foot-prints, especially the so-called "bird-tracks," which are generally supposed to have been made by birds, the tracks of which many of them closely resemble. A careful investigation, however, of nearly all the specimens yet discovered, has convinced me that there is not a particle of evidence that any of these fossil impressions were made by birds. Most of these three-toed tracks were certainly not made by birds; but by quadrupeds, which usually walked upon their hind feet alone, and only occasionally put to the ground their smaller anterior extremities. I have myself detected the impressions of these anterior limbs in connection with the posterior foot-prints of nearly all of the supposed "bird-tracks" described, and have little doubt that they will eventually be found with all. These double impressions are precisely the kind which Dinosaurian reptiles would make, and as the only characteristic bones yet found in the same rocks belong to animals of this group, it is but fair to attribute all these foot-prints to Dinosaurs, even where no impressions of fore-feet have been detected, until some evidence appears that they were made by Birds. I have no doubt that Birds existed at this time, although at present the proof is wanting.

The principal genera of Triassic Reptiles known from osseous remains in this country are, *Amphisaurus* (*Megadactylus*), from the Connecticut Valley, *Bathygnathus*, from Prince Edward's Island, *Belodon* and *Clepsysaurus*. Other generic names which have been applied to foot-prints and to fragmentary remains, need not be here enumerated. A few remains of Reptiles have been found in undoubted Jurassic rocks of America, but they are not sufficiently well determined to be

of service in this connection. Others have been reported from supposed Jurassic strata, which are now known to be Cretaceous. It will thus be seen that, although reptilian life was especially abundant during the Triassic and Jurassic periods, but few bones have been found. This is owing in part to the character of most of the rocks then formed, which were not well fitted for preserving such remains, although admirably adapted to retain foot-prints.

During the Cretaceous Period, Reptilian life in America attained its greatest development, and the sediments laid down in the open seas and estuaries were usually most favorable for the preservation of a faithful record of its various phases. Without such a perfect matrix as some of these deposits afford, many of the most interesting vertebrates recently brought to light from this formation would probably have remained unknown. The vast extent of these beds ensures, moreover, many future discoveries of interest.

In the lowest Cretaceous strata of the Rocky Mountain region, the Dakota group, part of which at least represents the Wealden of Europe, remains of *Chelonia*, or Turtles, Crocodiles, and Dinosaurs occur, the last being especially abundant. The *Chelonia*, although known from the Jurassic of Europe, here appear for the first time in American rocks. Some of the earliest forms are allied to the modern genus *Trionyx*. In the higher Cretaceous beds, some Chelonians of enormous size have been found. They belong to the genus *Atlantochelys*, which has the ribs separate, as in the existing *Sphargis*, and presents other embryonic characters. A few genera appear to be related to the modern genus *Chelone*. The remaining Cretaceous species were mostly of the Emydoid type; and others were related to *Chelydra*. The more important genera of Cretaceous Chelonians known from characteristic specimens are, *Atlantochelys* (*Protostega*), *Adocus*, *Bothremys*, *Compsemys*, *Plastomenus*, *Osteopygis*, *Propleura*, *Lytoloma*, and *Taphrosphys*. Most of these genera were represented by several species, and the individuals were numerous. No land Tortoises have as yet been found in this formation. In American Tertiary deposits, Chelonians are abundant, especially in the fresh-water beds. They all show near affinities with modern types, and most of them can be referred to existing genera. In the Tertiary lake-basins of the West, land Tortoises are very numerous, and with them are many fresh-water forms of *Trionyx* and allied genera.

A striking feature of the American Cretaceous fauna, as contrasted with that of Europe, is the almost entire absence in our strata of species of *Ichthyosaurus* and *Plesiosaurus*, which abound in many other regions, but here seem to be replaced by

the Mosasaurs. A few fragmentary remains have indeed been referred to these genera, but the determination may fairly be questioned. This is more than true of the proposed new order *Streptosauria*, which was founded wholly on error. The order *Plesiosauria*, however, is well represented, but mainly by forms more nearly related to the genus *Pliosaurus* than to the type of the group. These were marine reptiles, all of large size, while some of them attained vast dimensions. So far as at present identified, they may be referred to the genera, *Cimoliosaurus*, *Discosaurus* (*Elasmosaurus*), and *Pliosaurus*. The number of species is comparatively few, and none are known above the Cretaceous. The important suggestion of Gegenbaur, that the *Halisauria*, which include the Plesiosaurs, branched off from the Fishes before the Amphibians, finds some support in American specimens recently discovered.

The Reptiles most characteristic of our American Cretaceous strata are the *Mosasauria*, a group with very few representatives in other parts of the world. In our Cretaceous seas, they ruled supreme, as their numbers, size, and carnivorous habits, enabled them to easily vanquish all rivals. Some were at least sixty feet in length, and the smallest ten or twelve. In the inland Cretaceous sea from which the Rocky Mountains were beginning to emerge, these ancient "Sea Serpents" abounded; and many were entombed in its muddy bottom. On one occasion, as I rode through a valley washed out of this old ocean bed, I saw no less than seven different skeletons of these monsters in sight at once. The Mosasaurs were essentially swimming Lizards, with four well developed paddles, and they had little affinity with modern serpents, to which they have been compared. The species are quite numerous, but they belong to comparatively few genera, of which *Mosasaurus*, *Tylosaurus*, *Lestosaurus* and *Edestosaurus*, have alone been identified with certainty. The genus *Mosasaurus* was first found in Europe. All the known species of the group are Cretaceous.

The *Crocodilia* are abundant in rocks of Cretaceous age in America, and two distinct types are represented. The older type, which is foreshadowed by *Belodon* of the Trias, has biconcave vertebræ, and shows marked affinities with the genus *Teleosaurus*, from the Jura of Europe. The best known genus is *Hyposaurus*, of which there are several species, all more or less resembling in form the modern Gavial of the Ganges. A peculiar intermediate form is seen in *Diplosaurus*, from the Wealden of the Rocky Mountains. The second type, which now makes its appearance for the first time, has procœlian vertebræ, and in other respects resembles existing Crocodiles. The genera described are *Bottosaurus*, *Holops* and *Thoracosaurus*, none of which, so far as known, pass above the

Cretaceous. Of *Crocodilia* with opisthocœlous vertebræ, America, so far as we know, has none. Specimens similar to those so termed in Europe, are not uncommon here, but they pertain to Dinosaurs.

In the Eocene fresh-water beds of the West, Crocodilians are especially abundant, and all, with the exception of *Limnosaurus*, belong apparently to the genus *Crocodilus*, although some species show certain points of resemblance to existing Alligators. The Miocene lake-basins of the same region contain no remains of Crocodiles, so far as known, and the Pliocene deposits have afforded only a single species. The Tertiary marine beds of the Atlantic Coast contain comparatively few Crocodilian remains, and all are of modern types; the genus *Gavialis* having one Eocene species, and the Alligator being represented only in the latest deposits.

It is worthy of special mention in this connection, that no true *Lacertilia*, or Lizards, and no *Ophidia*, or Serpents, have yet been detected in American Cretaceous beds; although their remains, if present, would hardly have escaped observation in the regions explored. The former will doubtless be found, as several species occur in the Mesozoic of Europe; and perhaps the latter, although the Ophidians are apparently a more modern type. In the Eocene lake-basins of Western America, remains of Lizards are very numerous, and indicate species much larger than any existing to-day. Some of these, the *Glyptosauridæ*, were protected by a highly ornamented bony coat of mail, and others were covered with scales, like recent Lizards. A few resembled, in their more important characters, the modern Iguana. The genera best represented in the Eocene, are, *Glyptosaurus*, *Iguanavus*, *Oreosaurus*, *Thinosaurus*, *Tinosaurus* and *Sunira*. Some of these genera appear to have continued into the Miocene, but here, as well as in the Pliocene, few remains of this group have been found. It is not improbable that some of our extinct Reptiles may prove to belong to *Rynchocephala*, but at present this is uncertain. The genus *Notosaurus*, from Brazil, has biconcave vertebræ, and some other characters which point to that group. No Dicynodonts or Theriodonts have as yet been found in this country.

The first American Serpents, so far as now known, appear in the Eocene, which contains also the oldest European species. On the Atlantic border, the genus *Titanophis* (*Dinophis*) is represented by several species of large size, one at least thirty feet in length, and all doubtless inhabitants of the sea. In the fresh-water Western Eocene, remains of snakes are abundant, but all are of moderate size. The largest of these were related to the modern Boa Constrictors. The genera described are *Boavus*, *Lithophis* and *Limnophis*. The Miocene and Pliocene

Snakes from the same region are known only from a few fragmentary remains.

The *Pterosauria*, or flying Lizards, are among the most interesting Reptiles of Mesozoic time, and many of them left their remains in the soft sediments of our inland Cretaceous sea. These were veritable Dragons, having a spread of wings of from ten to twenty-five feet. They differed essentially from the smaller Pterodactyls found in the old world, in the entire absence of teeth, showing in this respect a resemblance to modern birds; and they possess other distinctive characters. They have therefore been placed in a new order, *Pteranodontia*, from the typical genus *Pteranodon*, of which five species are known. The only other genus is *Nyctosaurus*, represented by a single species. All the specimens yet found are from essentially the same horizon, in the Chalk of Kansas. The reported discovery of remains of this order from older formations in this country is without foundation.

The strange Reptiles known as *Dinosauria*, which, as we have seen, were numerous during the deposition of our Triassic shales and sandstones, have not yet been found in American Jurassic, but were well represented here throughout the Cretaceous, and at its close became extinct. These animals possess a peculiar interest to the anatomist, since, although reptilian in all their main characters, they show clear affinities with the Birds, and have some features which may point to Mammals. The Cretaceous Dinosaurs were all of large size, and most of them walked on the hind feet alone, like modern Struthious birds. Two well marked types may be distinguished among the remains discovered in deposits of this age: the herbivorous forms, represented mainly by *Hadrosaurus*, a near ally of the *Iguanodon* of Europe; and their carnivorous enemies, of which *Dryptosaurus* (*Lælaps*) may be considered typical in this country, and *Megalosaurus* in Europe. Near the base of our Cretaceous formation, in beds which I regard as the equivalent of the European Wealden, the most gigantic forms of this order yet discovered have recently been brought to light. One of these monsters (*Titanosaurus montanus*), from Colorado, is by far the largest land animal yet discovered; its dimensions being greater than was supposed possible, in an animal that lived and moved upon the land. It was some fifty or sixty feet in length, and, when erect, at least thirty feet in height. It doubtless fed upon the foliage of the mountain forests, portions of which are preserved with its remains. With *Titanosaurus*, the bones of smaller Dinosaurs, one (*Nanosaurus*) not larger than a Cat, as well as those of Crocodiles and Turtles, are not uncommon. The recent discovery of these interesting remains, many and various, in strata that had long been pro-

nounced by professional explorers barren of vertebrate fossils, should teach caution to those who decline to accept the imperfection of our knowledge to-day as a fair plea for the supposed absence of intermediate forms.

In the marine Cretaceous beds of the West, only a single Dinosaur (*Hadrosaurus agilis*), has been found, but in the higher fresh-water beds, which mark the close of this formation, their remains are numerous, and indicate several well marked species, if not genera. In the marine beds on the Atlantic Coast, the bones of Dinosaurs are frequently met with, and in the Upper Cretaceous Greensand of New Jersey, the type specimens of *Hadrosaurus* and *Dryptosaurus* were found. In Cretaceous fresh-water deposits on the coast of Brazil, remains of this order occur, but the specimens hitherto discovered are not sufficiently characteristic for accurate determination. This is unfortunately true of many Dinosaurian fossils from North America, but the great number of these Reptiles which lived here during the Cretaceous Period promises many future discoveries, and substantial additions to our present knowledge of the group.

The first appearance of Birds in America, according to our present knowledge, was during the Cretaceous Period, although many announcements have been made of their existence in preceding epochs. The evidence of their presence in the Trias, based on footprints and other impressions, is, at present, as we have seen, without value; although we may confidently await their discovery there, if not in older formations. *Archæopteryx*, from the European Jura, the oldest bird known, and now fortunately represented by more than a single specimen, clearly indicates a much higher antiquity for the class. The earliest American forms, at present known, are the *Odontornithes*, or Birds with teeth, which have been exhumed within the last few years, from the Chalk of Kansas. The two genera, *Hesperornis* and *Ichthyornis*, are types of distinct orders, and differ from each other and from *Archæopteryx* much more than do any existing birds among themselves; thus showing that Birds are now a closed type, and that the key to the history of the class must be sought for in the distant past.

In *Hesperornis*, we have a large aquatic bird, nearly six feet in length, with a strange combination of characters. The jaws are provided with teeth, set in grooves; the wings were rudimentary, and useless; while the legs were very similar to those of modern diving birds. This last feature was merely an adaptation, as the more important characters are Struthious, showing that *Hesperornis* was essentially a carnivorous swimming Ostrich. *Ichthyornis*, a small flying bird, was stranger still, as the teeth were in sockets; and the vertebræ biconcave, as in Fishes, and a few Reptiles. *Apatornis* and other allied forms occur

in the same beds, and probably all were provided with teeth. It is strange that the companions of these ancient toothed Birds should have been Pterodactyls without teeth. In the later Cretaceous beds of the Atlantic Coast, various remains of aquatic Birds have been found, but all are apparently distinct from those of the West. The known genera of American Cretaceous birds are, *Apatornis*, *Baptornis*, *Graculavus*, *Hesperornis*, *Ichthyornis*, *Laornis*, *Lestornis*, *Palæotringa* and *Telmatornis*. These are represented by some twenty species. In Europe, but two species of Cretaceous birds are known, and both are based upon fragmentary specimens.

During the Tertiary period, Birds were numerous in this country, and all yet discovered appear to have belonged to modern types. The Eocene species described are mostly wading birds, but here, and in the later Tertiary deposits, some characteristic American forms make their appearance, strongly foreshadowing our present avian fauna. The extinct genera are the Eocene *Uintornis*, related to the Woodpeckers, and *Aletornis*, which includes several species of Waders. Among the existing genera found in our Tertiary beds are, *Aquila*, *Bubo*, *Meleagris*, *Grus*, *Graculus*, *Puffinus*, *and Catarractes*. The Great Auk (*Alca impennis*), which was once very abundant on our Northeast Coast, has become extinct within a few years.

In this brief summary of the past life of Reptiles and Birds in America, I have endeavored to exclude doubtful forms, and those very imperfectly known, preferring to present the conclusions reached by careful study, incomplete though they be, rather than weary you with a descriptive catalogue of all the fossils to which names have been applied. Even this condensed review can hardly fail to give you some conception of the wealth of our continent in the extinct forms of these groups, and thus to suggest what its actual life must have been.

Although the Trias offers at present the first unquestioned evidence of true Reptiles, we certainly should not be justified in supposing for a moment that older forms did not exist. So too in considering the different groups of Reptiles, which seem to make their first appearance at certain horizons, flourish for a time, and then decline, or disappear, every day brings evidence to show that they are but fragments of the unraveled strands which converge in the past to form the mystic cord uniting all life. If the attempt is made to follow back any single thread, and thus trace the lineage of a group, we are met by difficulties which the science of to-day can only partially remove. And yet the anatomist constantly sees in the fragments which he studies hints of relationship which are to him sure prophecies of future discoveries.

The genealogy of the *Chelonia* is at present unknown, and

our American extinct forms, so far as we now have them, throw little light on their ancestry. This is essentially true, also, of our *Plesiosauria*, *Lacertilia* and *Ophidia*, although suggestive facts are not wanting to indicate possible lines of descent. With the *Crocodilia*, however, the case seems to be different, and Huxley has clearly pointed out the path for investigation. It is probable that material already exists in our museums for tracing the group through several important steps in its development. We have already seen that the modern procœlian type of this order goes back only to the Upper Cretaceous, while the *Belodonts*, of our Triassic rocks, with their biconcave vertebræ, are the oldest known Crocodilians. Our Jurassic, unfortunately, throws but little light on the intermediate forms, but we know that the line was continued, as it was in the old world through *Teleosaurus*. The beds of the Rocky Mountain Wealden have just furnished us with a genuine "missing link," a saurian (*Diplosaurus*) with essentially the skull and teeth of a modern Crocodile, and the vertebræ of its predecessor from the Trias. This peculiar reptile clearly represents an important stage in the progressive series, and evidently one soon after the separation of the Crocodile branch from the main stem. The modern Gavial type appears to have been developed about the same time, as the form was well established in the Upper Cretaceous genus, *Thoracosaurus*. The Teleosaurian group, with biconcave vertebræ, evidently the parent stock of Crocodilians, became extinct with *Hyposaurus* of the same horizon, leaving the Crocodile and Gavial, with their more perfect procœlian vertebræ, to contend for the supremacy. In the early Eocene, both of these types were abundant, but some of the Crocodiles possessed characters pointing towards the Alligators, which do not appear to have been completely differentiated until later.

Nothing is really known to-day of the earlier genealogy of the *Pterosauria*, but our American forms, without teeth, are clearly the last stage in their development before this peculiar group became extinct. The oldest European form, *Dimorphodon*, from the Lower Lias, had the entire jaws armed with teeth, and was provided with a long tail. The later genus *Pterodactylus* retained the teeth, but had essentially lost the tail; while *Ramphorhynchus* had retained the elongated tail, but had lost the teeth from the fore part of both jaws. In the genus *Pteranodon* from the American Cretaceous, the teeth are entirely absent, and the tail is a mere rudiment. In the gradual loss of the teeth and tail, these reptiles followed the same path as Birds, and might thus seem to approach them, as many have supposed. This resemblance, however, is only a superficial one, as a study of the more important characters of the Pterodactyls shows

that they are an aberrant type of Reptiles, totally off the line through which the Birds were developed. The announcement made not long since in Europe, and accepted by some American authors, that the *Pterosauria*, in consequence of certain points in their structure, were essentially Birds, is directly disproved by American specimens, far more perfect than those on which the conclusion was based.

It is now generally admitted by biologists who have made a study of the vertebrates, that Birds have come down to us through the Dinosaurs, and the close affinity of the latter with recent Struthious Birds will hardly be questioned. The case amounts almost to a demonstration, if we compare, with Dinosaurs, their contemporaries, the Mesozoic Birds. The classes of Birds and Reptiles, as now living, are separated by a gulf so profound that a few years since it was cited by the opponents of evolution as the most important break in the animal series, and one which that doctrine could not bridge over. Since then, as Huxley has clearly shown, this gap has been virtually filled by the discovery of bird-like Reptiles and reptilian Birds. *Compsognathus* and *Archæopteryx* of the Old World, and *Ichthyornis* and *Hesperornis* of the New, are the stepping stones by which the evolutionist of to-day leads the doubting brother across the shallow remnant of the gulf, once thought impassable.

It remains now to consider the highest group of the Animal Kingdom, the class *Mammalia*, which includes Man. Of the existence of this class before the Trias we have no evidence, either in this country or in the Old World, and it is a significant fact that at essentially the same horizon in each hemisphere, similar low forms of Mammals make their appearance. Although only a few incomplete specimens have been discovered, they are characteristic and well preserved, and all are apparently Marsupials, the lowest Mammalian group which we know in this country, living or fossil. The American Triassic Mammals are known at present only from two small lower jaws, on which is based the genus *Dromotherium*, supposed to be related to the insect-eating *Myrmecobius*, now living in Australia.

Although the Jura of Europe has yielded other similar Mammals, we have as yet none of this class from that formation; while, from rocks of Cretaceous age, no Mammals are known in any part of the world. This is especially to be regretted, as it is evidently to the Cretaceous that we must look for the first representatives of many of our present groups of Mammals, as well as for indications of their more ancient lineage. That some discovery of this nature from the Cretaceous is near at hand, I cannot doubt, when I consider what the last few years have brought to light in the Eocene.

In the lowest Tertiary beds of this country, a rich Mammalian fauna suddenly makes its appearance, and from that time through the Age of Mammals to the present, America has been constantly occupied by this type of life in the greatest diversity of form. Fortunately, a nearly continuous record of this life, as preserved, is now accessible to us, and ensures great additions to our knowledge of the genealogy of Mammals, and perhaps the solution of more profound problems. Before proceeding to discuss in detail American fossil *Mammalia*, it is important to define the divisions of time indicated in our Tertiary and Post-Tertiary deposits, as these in many cases mark successive stages in the development of the mammals.

The boundary line between the Cretaceous and Tertiary in the region of the Rocky Mountains has been much in dispute during the last few years, mainly in consequence of the uncertain geological bearings of the fossil plants found near this horizon. The accompanying invertebrate fossils have thrown little light on the question, which is essentially, whether the great Lignite series of the West is uppermost Cretaceous, or lowest Eocene. The evidence of the numerous vertebrate remains is, in my judgment, decisive, and in favor of the former view.

This brings up an important point in Palæontology, one to which my attention was drawn several years since, namely: the comparative value of different groups of fossils in marking geological time. In examining the subject with some care, I found that, for this purpose, plants, as their nature indicates, are most unsatisfactory witnesses; that invertebrate animals are much better; and that vertebrates afford the most reliable evidence of climatic and other geological changes. The subdivisions of the latter group, moreover, and in fact all forms of animal life, are of value in this respect, mainly according to the perfection of their organization, or zoological rank. Fishes, for example, are but slightly affected by changes that would destroy Reptiles or Birds, and the higher Mammals succumb under influences that the lower forms pass through in safety. The more special applications of this general law, and its value in geology, will readily suggest themselves.

The evidence offered by fossil remains is, in the light of this law, conclusive, that the line, if line there be, separating our Cretaceous from the Tertiary, must at present be drawn where the Dinosaurs and other Mesozoic vertebrates disappear, and are replaced by the Mammals, henceforth the dominant type.

The Tertiary of Western America comprises the most extensive series of deposits of this age known to geologists, and important breaks in both the rocks and the fossils separate it into three well-marked divisions. These natural divisions are not the exact equivalents of the Eocene, Miocene, and Pliocene

of Europe, although usually so considered, and known by the same names; but, in general, the fauna of each appears to be older than that of its corresponding representative in the other hemisphere; an important fact, not hitherto recognized. This partial resemblance of our extinct faunas to others in regions widely separated, where the formations are doubtless somewhat different in geological age, is precisely what we might expect, if, as was probable, the main migrations took place from this Continent. It is better at once to recognize this principle, rather than attempt to bring into exact parallelism, formations that were not strictly contemporaneous.

The freshwater Eocene deposits of our Western Territories, which are in the same region at least two miles in vertical thickness, may be separated into three distinct subdivisions. The lowest of these, resting unconformably on the Cretaceous, has been termed the Vermilion Creek, or Wahsatch, Group. It contains a well-marked mammalian fauna, the largest and most characteristic genus of which is the ungulate *Coryphodon*, and hence I have called these deposits the Coryphodon Beds. The middle Eocene strata, which have been termed the Green River and Bridger Series, may be designated as the Dinoceras Beds, as the gigantic animals of this order are only found here. The uppermost Eocene, or the Uintah Group, is especially well characterized by large mammals of the genus *Diplacodon*, and hence may be termed the Diplacodon Beds. The fauna of each of these three subdivisions was essentially distinct, and the fossil remains of each were entombed in different and successive ancient lakes. It is important to remember that these Eocene lake-basins all lie between the Rocky Mountains on the east and the Wahsatch Range on the west, or along the high central plateau of the Continent. As these mountain chains were elevated, the enclosed Cretaceous sea, cut off from the ocean, gradually freshened, and formed these extensive lakes, while the surrounding land was covered with a luxuriant tropical vegetation, and with many strange forms of animal life. As the upward movement of this region continued, these lake-basins, which for ages had been filling up, preserving in their sediments a faithful record of Eocene life-history, were slowly drained by the constant deepening of the outflowing rivers, and they have since remained essentially dry land.

The Miocene lake-basins are on the flanks of this region, where only land had been since the close of the Cretaceous. These basins contain three faunas, nearly or quite distinct. The lowest Miocene, which is only found east of the Rocky Mountains, alone contains the peculiar mammals known as the *Brontotheridæ*, and these deposits may be called the Brontotherium Beds. The strata next above, which represent the middle Mio-

cene, have as their most characteristic fossil the genus *Oreodon*, and are known as the Oreodon Beds. The upper Miocene, which occurs in Oregon, is of great thickness, and from one of its most important fossils, *Miohippus*, may be designated as the Miohippus Series. The climate here during this period was warm temperate.

Above the Miocene, east of the Rocky Mountains and on the Pacific Coast, the Pliocene is well developed, and is rich in vertebrate remains. The strata rest unconformably on the Miocene, and there is a well marked faunal change at this point, modern types now first making their appearance. For these reasons, we are justified in separating the Miocene from the Pliocene at this break; although in Europe where no marked break exists, the line seems to have been drawn at a somewhat higher horizon. Our Pliocene forms essentially a continuous series, although the upper beds may be distinguished from the lower by the presence of a true *Equus*, and some other existing genera. The Pliocene climate was similar to that of the Miocene. The Post-Pliocene beds contain many extinct mammals, and may thus be separated from recent deposits.

Returning now to our subject from this geological digression, —which will hardly be deemed unprofitable, since I have given you in few words the results of a great deal of hard mountain work,—let us consider the Tertiary mammals, as we know them from the remains already discovered, and attempt to trace the history of each order down to the present time. We have seen that a single small Marsupial, from the Trias, is the only mammal found in all the American rocks below the Eocene; and yet in beds of this age, immediately over the Chalk, fossil mammals of many different kinds abound.

The Marsupials, strange to say, are here few in number, and diminutive in size; and have as yet been identified only by fragmentary specimens, and most of them too imperfect for accurate description. In the higher Eocene deposits, this group is more abundant, but still represented by small animals, most of them insectivorous, or carnivorous in habit, like the existing Opossum. From the Miocene and Pliocene, no remains of Marsupials have been described. From the Post-Tertiary, only specimens nearly allied to those now living are known, and most of these were found in the caves of South America.

The Edentate Mammals are evidently an American type, and on this Continent attained a great development in numbers and size. No Eocene Edentates have been found here, and although their discovery in this formation has been announced, the identification proves to have been erroneous. In the Miocene of the Pacific Coast, a few fossils have been discovered which belong to animals of this group, and to the genus *Moropus*.

There are two species, one about as large as a Tapir, and the other nearly twice that size. This genus is the type of a distinct family, the *Moropodidæ*. In the lower Pliocene above, well preserved remains of Edentates of very large size have been found at several widely separated localities in Idaho and California. These belong to the genus *Morotherium*, of which two species are known. East of the Rocky Mountains, in the lower Pliocene of Nebraska, a large species apparently of the genus *Moropus* has been discovered. The horizon of these later fossils corresponds nearly with beds in Europe that have been called Miocene. In the Post-Pliocene of North America, gigantic Edentates were very numerous and widely distributed, but all disappeared with the close of that period. These forms were essentially huge Sloths, and the more important genera were *Megatherium*, *Mylodon* and *Megalonyx*. The genera *Megalocnus* and *Myomorphus* have been found only in Cuba.

In South America during the Pliocene or Post-Pliocene, enormous Edentates were still more abundant, and their remains are usually in such perfect preservation as to suggest a very recent period for their extinction. The Sloth tribe is represented by the huge *Mylodon*, *Megatherium*, *Megalonyx*, *Cœlodon*, *Ochotherium*, *Gnathopis*, *Lestodon*, *Scelidotherium*, and *Sphænodon;* and among the Armadilloes were *Chlamydotherium*, *Eurydon*, *Glyptodon*, *Heterodon*, *Pachytherium* and *Schistopleurum*. *Glossotherium*, another extinct genus, is supposed to be allied to the Ant-eaters.

It is frequently asserted, and very generally believed, that the large number of huge *Edentata* which lived in North America during the Post-Pliocene, were the results of an extensive migration from South America soon after the elevation of the Isthmus of Panama, near the close of the Tertiary. No conclusive proof of such migration has been offered, and the evidence, it seems to me, so far as we now have it, is directly opposed to this view. No undoubted Tertiary Edentates have yet been discovered in South America, while we have at least two species in our Miocene, and during the deposition of our lower Pliocene, large individuals of this group were not uncommon as far north as the forty-third parallel of latitude, on both sides of the Rocky Mountains. In view of these facts, and others which I shall lay before you, it seems more natural to conclude from our present knowledge, that the migration, which no doubt took place, was from north to south. The Edentates finding thus in South America a congenial home flourished greatly for a time, and although the larger forms are now all extinct, diminutive representatives of the group still inhabit the same region.

The *Cetacea* first appear in the Eocene, as in Europe, and

are comparatively abundant in deposits of this age on the Atlantic Coast. The most interesting remains of this order, yet found, belong to the *Zeuglodontidæ*, which are carnivorous whales, and the only animals of the order with teeth implanted by two roots. The principal genera of this family are *Zeuglodon* and *Squalodon*, the former genus being represented by gigantic forms, some of which were seventy feet in length. The genus *Saurocetes*, which includes some small animals of this group, has been found in South America. The Dolphin family (*Delphinidæ*) are well represented in the Miocene, both on the Atlantic and Pacific Coast. The best known genus is *Priscodelphinus*, of which several species have been described. Several other generic names which have been applied to fragments need not here be enumerated. In none of the Tertiary species of this family were the cervical vertebræ ankylosed. The Sperm Whales (*Catodontidæ*) were also abundant throughout the Tertiary, and with them in the earlier beds, various Ziphioid forms have been found. The toothless *Balænidæ* are only known with certainty as fossils from the later Tertiary and more recent deposits.

The Sirenians, which appear first in the Eocene of the Old World, occur in the Miocene of our Eastern Coast, and throughout the later Tertiary. The specimens described have all been referred to the genus *Manatus*, and seem closely related to our living species. In the Tertiary of Jamaica, a skull has been found which indicates a new genus, *Prorastomus*, also allied to the existing Manatee. The genus *Rhytina*, once abundant on our Northwest Coast, has recently become extinct.

The Ungulates are the most abundant Mammals in the Tertiary, and the most important; since they include a great variety of types, some of which we can trace through their various changes down to the modified forms that represent them to-day. Of the various divisions in this comprehensive group, the Perissodactyle, or odd-toed Ungulates, are evidently the oldest, and throughout the Eocene are the prevailing forms. Although all of the Perissodactyles of the earlier Tertiary are more or less generalized, they are still quite distinct from the Artiodactyles, even at the base of the Eocene. One family, however, the *Coryphodontidæ*, which is well represented at this horizon, both in America and Europe, although essentially *Perissodactyle*, possesses some characters which point to a primitive Ungulate type from which the present orders have been evolved. Among these characters are the diminutive brain, which in size and form approaches that of the Reptiles, and also the five-toed feet from which all the various forms of the mammalian foot have been derived. Of this family, only a single genus, *Coryphodon* (*Bathmodon*), is known, but there

were several distinct species. They were the largest mammals of the lower Eocene, some exceeding in size the existing Tapirs.

In the middle Eocene, West of the Rocky Mountains, a remarkable group of ungulates makes its appearance. These animals nearly equaled the Elephant in size, but had shorter limbs. The skull was armed with two or three pairs of horn-cores, and with enormous canine tusks. The brain was proportionally smaller than in any other land mammal. The feet had five toes, and resembled in their general structure those of *Coryphodon*, thus indicating some affinity with that genus. These mammals resemble in some respects the Perissodactyles, and in others the Proboscidians, yet differ so widely from any known Ungulates, recent or fossil, that they must be regarded as forming a distinct order, the *Dinocerata*. Only three genera are known, *Dinoceras*, *Tinoceras* and *Uintatherium*, but quite a number of species have been described. During the later part of the middle Eocene, these animals were very abundant for a short time, and then became extinct, leaving apparently no successors, unless possibly we have in the Proboscidians their much modified descendants. Their genetic connection with the Coryphodonts is much more probable, in view of what we now know of the two groups.

Besides these peculiar Mammals, which are extinct, and mainly of interest to the Biologist, there were others in the early Tertiary which remind us of those at present living around us. When a student in Germany some twelve years ago, I heard a world-renowned Professor of Zoology gravely inform his pupils that the Horse was a gift of the Old World to the New, and was entirely unknown in America until introduced by the Spaniards. After the lecture, I asked him whether no earlier remains of horses had been found on this Continent, and was told in reply that the reports to that effect were too unsatisfactory to be presented as facts in science. This remark led me, on my return, to examine the subject myself, and I have since unearthed, with my own hands, not less than thirty distinct species of the horse tribe, in the Tertiary deposits of the West alone; and it is now, I think generally admitted that America is, after all, the true home of the Horse.

I can offer you no better illustration than this of the advance vertebrate palæontology has made during the last decade, or of the important contributions to this progress which our Rocky Mountain region has supplied.

The oldest representative of the horse, at present known, is the diminutive *Eohippus* from the lower Eocene. Several species have been found, all about the size of a fox. Like most of the early mammals, these Ungulates had forty-four teeth, the molars with short crowns, and quite distinct in form from

the premolars. The ulna and the fibula were entire and distinct, and there were four well developed toes and a rudiment of another on the fore feet, and three toes behind. In the structure of the feet, and in the teeth, the *Eohippus* indicates unmistakably that the direct ancestral line to the modern horse has already separated from the other Perissodactyles. In the next higher division of the Eocene, another genus (*Orohippus*) makes its appearance, replacing *Eohippus*, and showing a greater, although still distant, resemblance to the Equine type. The rudimentary first digit of the fore foot has disappeared, and the last premolar has gone over to the molar series. *Orohippus* was but little larger than *Eohippus*, and in most other respects very similar. Several species have been found in the same horizon with *Dinoceras*, and others lived during the upper Eocene with *Diplacodon*, but none later.

Near the base of the Miocene, in the Brontotherium beds, we find a third closely allied genus, *Mesohippus*, which is about as large as a sheep, and one stage nearer the horse. There are only three toes and a rudimentary splint bone on the fore feet, and three toes behind. Two of the premolar teeth are quite like the molars. The ulna is no longer distinct, or the fibula entire, and other characters show clearly that the transition is advancing. In the upper Miocene, *Mesohippus* is not found, but in its place a fourth form, *Miohippus*, continues the line. This genus is near the *Anchitherium* of Europe, but presents several important differences. The three toes in each foot are more nearly of a size, and a rudiment of the fifth metacarpal bone is retained. All the known species of this genus are larger than those of *Mesohippus*, and none pass above the Miocene.

The genus *Protohippus* of the lower Pliocene, is yet more equine, and some of its species equaled the ass in size. There are still three toes on each foot, but only the middle one, corresponding to the single toe of the horse, comes to the ground. This genus resembles most nearly the *Hipparion* of Europe. In the Pliocene, we have the last stage of the series before reaching the horse, in the genus *Pliohippus*, which has lost the small hooflets, and in other respects is very equine. Only in the upper Pliocene, does the true *Equus* appear, and complete the genealogy of the Horse, which in the Post-Tertiary roamed over the whole of North and South America, and soon after became extinct. This occurred long before the discovery of the Continent by Europeans, and no satisfactory reason for the extinction has yet been given. Besides the characters I have mentioned, there are many others, in the skeleton, skull, teeth, and brain of the forty or more intermediate species, which show that the transition from the Eocene *Eohippus* to the modern *Equus*, has taken place in the order indicated, and I

believe the specimens now at New Haven will demonstrate the fact to any anatomist. They certainly carried prompt conviction to the first of anatomists, who was the honored guest of the Association a year ago, whose genius had already indicated the later genealogy of the horse in Europe, and whose own researches so well qualified him to appreciate the evidence here laid before him. Did time permit, I might give you at least a probable explanation of this marvellous change, but justice to the comrades of the horse in his long struggle for existence demands that some notice of their efforts should be placed on record.

Beside the Horse and his congeners, the only existing Perissodactyles are the Rhinoceros and the Tapir. The last is the oldest type, but the Rhinoceros had near allies throughout the Tertiary; and, in view of the continuity of the equine line, it is well worth while to attempt to trace his pedigree. At the bottom of the Eocene, in our Western lake-basins, the tapiroid genus *Helaletes* is found, represented by numerous small mammals hardly larger than the diminutive horses of that day. In the following epoch of the Eocene, the closely allied *Hyrachyus* was one of the most abundant animals. This genus was nearly related to the *Lophiodon* of Europe, and in its teeth and skeleton strongly resembled the living Tapir; whose ancestry, to this point, seems to coincide with that of the Rhinoceros we are considering. Strangely enough, the Rhinoceros line, before it becomes distinct, separates into two branches. In the upper part of the Dinoceras Beds, we have the genus *Colonoceras*, which is really a *Hyrachyus* with a transverse pair of very rudimentary horn-cores on the nasal bones. In the lower Miocene west of the Rocky Mountains, this line seems to pass on through the genus *Diceratherium*, and in the higher Miocene this genus is well represented. Some of the species nearly equaled in size the existing Rhinoceros, which *Diceratherium* strongly resembled. The main difference between them is a most interesting one. The rudimentary horn-cores on the nasals, seen in *Colonoceras*, are in *Diceratherium* developed into strong bony supports for horns, which were placed transversely, as in the Ruminants, and not on the median line, as in all existing forms of Rhinoceros. In the Pliocene of the Pacific Coast, a large Rhinoceros has been discovered, which may be a descendant of *Diceratherium*, but as the nasal bones have not been found, we must wait for further evidence on this point. Returning now to the other branch of the Rhinoceros group, which left their remains mainly East of the Rocky Mountains, we find that all the known forms are hornless. The upper Eocene genus *Amynodon* is the oldest known Rhinoceros, and by far the most generalized of the family.

The premolars are all unlike the molars, the four canines are of large size, but the inner incisor in each jaw is lost in the fully adult animal. The nasals were without horns. There were four toes in front, and three behind. The genus *Hyracodon*, of the Miocene, which is essentially a Rhinoceros, has a full set of incisor and canine teeth; and the molars are so nearly like those of its predecessor *Hyrachyus*, that no one will question the transformation of the older into the newer type. *Hyracodon*, however, appears to be off the true line, for it has but three toes in front. In the higher Miocene beds, and possibly with *Hyracodon*, occurs a larger Rhinoceros, which has been referred to the genus *Aceratherium*. This form has lost the canine and one incisor above, and two incisors below. In the Pliocene are several species closely related, and of large size. Above the Pliocene in America, no vestiges of the Rhinoceros have been found, and our American forms doubtless became extinct at the close of this period.

The Tapir is clearly an old American type, and we have seen that, in the Eocene, the genera *Helaletes* and *Hyrachyus* were so strongly tapiroid in their principal characters, that the main line of descent probably passed through them. It is remarkable that the Miocene of the West, so greatly developed as it is on both sides of the Rocky Mountains, should have yielded but a few fragments of tapiroid mammals, and the same is true of the Pliocene of that region. In the Miocene of the Atlantic Coast, too, only a few imperfect specimens have been found. These forms all apparently belong to the genus *Tapiravus*, although most of them have been referred to *Lophiodon*, a lower Eocene type. In the Post-Tertiary, a true *Tapirus* was abundant, and its remains have been found in various parts of North America. The line of descent, although indistinct through the middle and upper Tertiary, was doubtless continuous in America, and several species exist at present, from Mexico southward. It is worthy of notice that the species North of the Isthmus of Panama appear all to be generically distinct from those of South America.

In addition to these three Perissodactyle types which, as the fittest, have alone survived, and whose lineage I have endeavored to trace, there were many others in early Tertiary times. Some of these disappeared with the close of the Eocene, while others continued, and assumed strange specialized shapes in the Miocene, before their decline and extinction. One series of the latter deserves especial mention, as it includes one of the most interesting families of our extinct animals. Among the large mammals in the lower Eocene is *Limnohyus*, a true Perissodactyle, but only known here from fragments of the skeleton. In the next higher beds, this genus is well

represented, and with it is found a nearly allied form, *Palæosyops*. In the upper Eocene, both have left the field, and the genus *Diplacodon*, a very near relative, holds the supremacy. The line seems clear through these three genera, but on crossing the break into the Miocene, we have, apparently as next of kin, the huge *Brontotheridæ*. These strange beasts show in their dentition and some other characters the same transition steps beyond *Diplacodon*, which that genus had made beyond *Palæosyops*. The *Brontotheridæ* were nearly as large as the Elephant, but had much shorter limbs. The skull was elongated, and had a transverse pair of large horn-cores on the maxillaries, in front of the orbits, like the middle pair in *Dinoceras*. There were four toes in front, and three behind, and the feet were similar to those of the Rhinoceros. There are four genera in this group, *Brontotherium; Diconodon; Menodus* (*Titanotherium*); and *Megacerops*, which have been found only in the lowest Miocene, east of the Rocky Mountains.

In the higher Miocene beds of Oregon, an allied genus, *Chalicotherium*, makes its appearance. It is one stage further on in the transition, and perhaps a descendant of the *Brontotheridæ;* but here, so far as now known, the line disappears. It is a suggestive fact, that this genus has now been found in Western America, China, India, Greece, Germany and France, indicating thus, as I believe, the path by which many of our ancient mammals helped to people the so-called Old World.

The Artiodactyles, or even-toed Ungulates, are the most abundant of the larger mammals now living; and the group dates back at least to the lowest Eocene. Of the two well marked divisions of this order, the Bunodonts and the Selenodonts, as happily defined by Kowalevsky, the former is the older type, which must have separated from the Perissodactyle line after the latter had become differentiated from the primitive Ungulate. In the Coryphodon Beds of New Mexico, occurs the oldest Artiodactyle yet found, but it is at present known only from fragmentary specimens. These remains are clearly Suilline in character, and belong to the genus *Eohyus*. In the beds above, and possibly even in the same horizon, the genus *Helohyus* is not uncommon, and several species are known. The molar teeth of this genus are very similar to those of the Eocene *Hyracotherium*, of Europe, which is supposed to be a Perissodactyle, while *Helohyus* certainly is not, but apparently a true lineal ancestor of the existing pigs. In every vigorous primitive type which was destined to survive many geological changes, there seems to have been a tendency to throw off lateral branches, which became highly specialized and soon died out, because they are unable to adapt themselves to new conditions. The narrow path of the persistent Suilline

type, throughout the whole Tertiary, is strown with the remains of such ambitious offshoots, while the typical pig, with an obstinacy never lost, has held on in spite of Catastrophes and Evolution, and still lives in America to-day. In the lower Eocene, we have in the genus *Parahyus* apparently one of these short-lived, specialized branches. It attained a much larger size than the true lineal forms, and the number of its teeth was reduced. In the Dinoceras Beds, or middle Eocene, we have still, on or near the true line, *Helohyus*, which is the last of the series known from the American Eocene. All these early Suillines, with the possible exception of *Parahyus*, appear to have had at least four toes, all of usable size.

In the lower Miocene, we find the genus *Perchœrus*, seemingly a true Suilline, and with it remains of a larger form, *Elotherium*, are abundant. The latter genus occurs in Europe in nearly the same horizon, and the specimens known from each Continent agree closely in general characters. The name *Pelonax* has been applied erroneously to some of the American forms; but the specimens on which it was based clearly belong to *Elotherium*. This genus affords another example of the aberrant Suilline offshoots, already mentioned. Some of the species were nearly as large as a Rhinoceros, and in all there were but two serviceable toes; the outer digits, seen in living animals of this group, being represented only by small rudiments concealed beneath the skin. In the upper Miocene of Oregon, Suillines are abundant, and almost all belong to the genus *Thinohyus*, a near ally of the modern Peccary (*Dicotyles*), but having a greater number of teeth, and a few other distinguishing features. In the Pliocene, Suillines are still numerous, and all the American forms yet discovered are closely related to *Dicotyles*. The genus *Platygonus* is represented by several species, one of which was very abundant in the Post-Tertiary of North America, and is apparently the last example of a side branch, before the American Suillines culminate in existing Peccaries. The feet in this species are more specialized than in the living forms, and approach some of the peculiar features of the ruminants; as for example a strong tendency to coalescence in the metapodial bones. The genus *Platygonus* became extinct in the Post-Tertiary, and the later and existing species are all true Peccaries. No authenticated remains of the genera *Sus*, *Porcus*, *Phacochœrus*, or the allied *Hippopotamus*, the Old World Suillines, have been found in America, although several announcements to that effect have been made.

In the series of generic forms between the lower Eocene *Eohyus* and the existing *Dicotyles*, which I have very briefly discussed, we have apparently the ancestral line ending in the typical American Suillines. Although the demonstration is

not yet as complete as in the lineage of the Horse, this is not owing to want of material, but rather to the fact that the actual changes which transformed the early Tertiary pig into the modern Peccary were comparatively slight, so far as they are indicated in the skeletons preserved, while the lateral branches were so numerous as to confuse the line. It is clear, however, that from the close of the Cretaceous to the Post-Tertiary, the Bunodont Artiodactyles were especially abundant on this Continent, and only recently have approached extinction.

The Selenodont division of the Artiodactyles is a more interesting group and, so far as we now know, makes its first appearance in the upper Eocene of the West, although forms, apparently transitional, between it and the Bunodonts occur in the Dinoceras Beds, or middle Eocene. These belong to the genus *Homacodon*, which is very nearly allied to *Helohyus* and but a single step away from this genus toward the Selenodonts. By a fortunate discovery, a nearly complete skeleton of this rare intermediate form has been brought to light, and we are thus enabled to define its characters. Several species of *Homacodon* are known, all of small size. This primitive Selenodont had forty-four teeth, which formed a nearly continuous series.

The molar teeth are very similar to those of *Helohyus*, but the cones on the crowns have become partially triangular in outline, so that when worn, the Selenodont pattern is clearly recognizable. The first and second upper molars, moreover, have three distinct posterior cusps, and two in front: a peculiar feature, which is seen also in the European genera *Dichobune* and *Cainotherium*. There were four toes on each foot, and the metapodial bones were distinct. The type species of this genus was about as large as a cat. With *Helohyus*, this genus forms a well marked family, the *Helohyidæ*.

In the *Diplacodon* horizon of the upper Eocene, the Selenodont dentition is no longer doubtful, as it is seen in most of the *Artiodactyla* yet found in these beds. These animals are all small, and belong to at least three distinct genera. One of these, *Eomeryx*, closely resembles *Homacodon* in most of its skeleton, and has four toes, but its teeth show well marked crescents, and a partial transition to the teeth of *Hyopotamus*, from the Eocene of Europe. With this genus, is another (*Parameryx*), also closely allied to *Homacodon*, but apparently a straggler from the true line, as it has but three toes behind. The most pronounced Selenodont in the upper Eocene is the *Oromeryx*, which genus appears to be allied to the existing Deer family, or *Cervidæ*, and if so is the oldest known representative of the group. These facts are important, as it has

been supposed, until very recently, that our Eocene contained no even-hoofed mammals.

In the lowest Miocene of the West, no true crescent-toothed *Artiodactyla* have as yet been identified, with the exception of a single species of *Hyopotamus;* but in the overlying beds of the middle Miocene, remains of the *Oreodontidæ* occur in such vast numbers as to indicate that these animals must have lived in large herds around the borders of the lake-basins in which their remains have been entombed. These basins are now the denuded deserts so well termed *Mauvaises Terres* by the early French trappers. The least specialized, and apparently the oldest, genus of this group is *Agriochœrus*, which so nearly resembles the older *Hyopotamus*, and the still more ancient *Eomeryx*, that we can hardly doubt that they all belonged to the same ancestral line. The typical Oreodonts are the genera *Oreodon* and *Eporeodon*, which have been aptly termed by Leidy, ruminating hogs. They had forty-four teeth, and four well developed toes on each foot. The true Oreodons, which were most numerous east of the Rocky Mountains, were about as large as the existing Peccary, while *Eporeodon*, which was nearly twice this size, was very abundant in the Miocene of the Pacific slope.

In the succeeding Pliocene formation, on each side of the Rocky Mountains, the genus *Merychyus* is one of the prevailing forms, and continues the line on from the Miocene, where the true Oreodons became extinct. Beyond this, we have the genus *Merycochœrus*, which is so nearly allied to the last, that they would be united by many naturalists. With the close of the Pliocene, this series of peculiar ruminants abruptly terminates, no member surviving until the Post-Tertiary, so far as known.

A most interesting line, that leading to the Camels and Llamas, separates from the primitive Selenodont branch in the Eocene, probably through the genus *Parameryx*. In the Miocene, we find in *Pœbrotherium* and some nearly allied forms unmistakable indications that the Cameloid type of ruminant had already become partially specialized, although there is a complete series of incisor teeth, and the metapodial bones are distinct. In the Pliocene, the Camel tribe was, next to the Horses, the most abundant of the larger mammals. The line is continued through the genus *Procamelus*, and perhaps others, and in this formation the incisors first begin to diminish, and the metapodials to unite. In the Post-Tertiary we have a true *Auchenia*, represented by several species, and others in South America, where the Alpacas and Llamas still survive. From the Eocene almost to the present time, North America has been the home of vast numbers of the *Camelidæ*, and there can be little doubt that they originated here, and migrated to the Old World.

Returning once more to the upper Eocene, we find another line of descent starting from *Oromeryx*, which, as we have seen, had apparently then just become differentiated from the older Bunodont type. Throughout the middle and upper Miocene, this line is carried forward by the genus *Leptomeryx* and its near allies, which resemble so strongly the Pliocene *Cervidæ* that they may fairly be regarded as their probable progenitors. Possibly some of these forms may be related to the *Tragulidæ*, but at present the evidence is against it.

The Deer family has representatives in the upper Miocene of Europe, which contains fossils strongly resembling the fauna of our lower Pliocene, a fact always to be borne in mind in comparing the horizon of any group in the two continents. Several species of *Cervidæ*, belonging to the genus *Cosoryx*, are known from the lower Pliocene of the West, and all have very small antlers, divided into a single pair of tynes. The statement recently published, that most of these antlers had been broken during the life of the animals, is unsupported by any evidence, and is erroneous. These primitive Deer do not have the orbit closed behind, and they have all the four metapodial bones entire, although the second and fifth are very slender. In the upper Pliocene, a true *Cervus* of large size has been discovered. In the Post-Tertiary, *Cervus*, *Alces*, and *Tarandus* have been met with, the latter far south of its present range. In the caves of South America, remains of *Cervus* have been found, and also two species of Antelopes, one referred to a new genus, *Leptotherium*.

The Hollow-horned Ruminants, in this country, appear to date back no further than to the lower Pliocene, and here only two species of *Bison* have as yet been discovered. In the Post-Tertiary this genus was represented by numerous individuals and several species, some of large size. The Musk Ox (*Ovibos*) was not uncommon during some parts of this epoch, and its remains are widely distributed.

No authentic fossil remains of true Sheep, Goats, or Giraffes have as yet been found on this continent.

The Proboscideans, which are now separated from the typical Ungulates as a distinct order, make their first appearance in North America in the lower Pliocene, where several species of *Mastodon* have been found. This genus occurs, also, in the upper Pliocene, and in the Post-Tertiary; although some of the remains attributed to the latter are undoubtedly older. The Pliocene species all have a band of enamel on the tusks, and some other peculiarities observed in the oldest Mastodons of Europe, which are from essentially the same horizon. Two species of this genus have been found in South America, in connection with the remains of extinct Llamas and Horses. The genus *Elephas* is a later form, and has not yet been iden-

tified in this country below the upper Pliocene, where one gigantic species was abundant. In the Post-Pliocene, remains of this genus are numerous. The hairy Mammoth of the Old World (*Elephas primigenius*) was once abundant in Alaska, and great numbers of its bones are now preserved in the frozen cliffs of that region. This species does not appear to have extended east of the Rocky Mountains, or south of the Columbia River, but was replaced there by the American Elephant, which preferred a milder climate. Remains of the latter have been met with in Canada, throughout the United States, and in Mexico. The last of the American Mastodons and Elephants became extinct in the Post-Tertiary.

The order *Toxodontia* includes two very peculiar genera, *Toxodon* and *Nesodon*, which have been found in the Post-Tertiary deposits of South America. These animals were of huge size, and possessed such mixed characters that their affinities are a matter of considerable doubt. They are thought to be related to the Ungulates, Rodents, and Edentates, but as the feet are unknown, this cannot at present be decided.

Macrauchenia and *Homalodontotherium* are two other peculiar genera from South America, now extinct, the exact affinities of which are uncertain. *Anoplotherium* and *Palæotherium*, so abundant in Europe, have not been found in our North American Tertiary deposits, although reported from South America.

Perhaps the most remarkable mammals yet found in America are the *Tillodontia*, which are comparatively abundant in the lower and middle Eocene. These animals seem to combine the characters of several different groups, viz: the Carnivores, Ungulates, and Rodents. In the genus *Tillotherium*, the type of the order, and of the family *Tillotheridæ*, the skull resembles that of the Bears; the molar teeth are of the ungulate type; while the large incisors are very similar to those of Rodents. The skeleton resembles that of the Carnivores, but the scaphoid and lunar bones are distinct, and there is a third trochanter on the femur. The feet are plantigrade, and each had five digits, all with long pointed claws. In the allied genus *Stylinodon*, which belongs to a distinct family, the *Stylinodontidæ*, all the teeth were rootless. Some of these animals were as large as a Tapir. The genus *Dryptodon* has been found only in the *Coryphodon* beds of New Mexico, while *Tillotherium* and *Stylinodon* occur in the middle Eocene of Wyoming. *Anchippodus* probably belongs to this group, which may perhaps include some other forms that have been named from fragmentary specimens.

The Rodents are an ancient type, and their remains are not unfrequently disinterred in the strata of our lowest fresh-water

Eocene. The earliest known forms are apparently all related to the Squirrels, and the most common genus is *Sciuravus*, which continued throughout the Eocene. A nearly allied form, which may prove to be the same, is *Paramys*, the species of which are larger than those of the older type. In the Dinoceras beds, the genus *Colonomys* is found, and the specimens preserved point to the *Muridæ*, as the nearest living allies. A peculiar genus, *Apatemys*, which also occurs in the middle Eocene, has gliriform incisors, but the molars resemble those of Insectivores. All the Eocene Rodents are of small size, the largest being about as large as a rabbit.

In the middle and upper Miocene lake-basins of the West, Rodents abound, but all are of moderate size. The Hares first appear in the Oreodon beds, and continue in considerable numbers through the rest of the Tertiary and Post-Tertiary to the present day. In these beds, the most common forms belong to the *Leporidæ*, and mainly to the genus *Palæolagus*. The Squirrel family is represented by *Ischyromys*, the *Muridæ* by the genus *Eumys*, and the Beavers by *Palæocastor*. In the upper Miocene of Oregon, most of the same genera are found, and with them some peculiar forms, very unlike anything now living. One of these is the genus *Allomys*, possibly related to the flying Squirrels, but having molar teeth somewhat like those of the Ungulates. In the Pliocene, east and west of the Rocky Mountains, Rodents continue abundant, but most of them belong to existing genera. Among these are *Castor*, *Hystrix*, *Cynomys*, *Geomys*, *Lepus* and *Hesperomys*. In the Post-Tertiary, the gigantic beaver, *Castoroides*, was abundant throughout most of North America. *Hydrochærus* has been found in South Carolina. In the caves of the island of Anguilla, in the West Indies, remains of large extinct Rodents belonging to the *Chinchillidæ* have been discovered.

The early Tertiary Rodents known from South America are the genera *Megamys*, *Theridromys*, and a large species referred to *Arvicola*. In Brazil, the Pliocene Rodents found are referred to the existing genera *Cavia*, *Kerodon*, *Lagostomus*, *Ctenomys*, *Hesperomys*, *Oxymycterus*, *Arvicola* and *Lepus*. A new genus, *Cardiodus*, described from this horizon, is a true Rodent, but the peculiar *Typotherium*, which has been referred to this order by some authorities, has perhaps other affinities. In the Post-Tertiary, the Rodents were very abundant in South America, as they are at present. The species are in most instances distinct from those now living, but the genera are nearly the same. The *Caviidæ* were especially numerous. *Cercolabes*, *Myopotamus*, and *Lagostomus* are also found, and two extinct genera, *Phyllomys* and *Lonchophorus*.

The *Cheiroptera*, or Bats, have not been found in this country

below the middle Eocene, where two extinct genera, *Nyctilestes* and *Nyctitherium*, are each represented by numerous remains. These fossils all belong to small animals, and, so far as they have been investigated, show no characters of more than generic importance to distinguish them from the Bats of to-day. No other members of this group are known from our Tertiary. In the Post-Tertiary, no extinct species of Bats have been found in North America, but from the caves of Brazil quite a number have been reported. These all belong to genera still living in South America, and most of them to the family *Phyllostomidæ*.

The Insectivores date back, in this country, at least to the middle Eocene. Here numerous remains occur, which have been described as belonging to this order, although it is possible that some of them were insect-eating Marsupials. The best known genera are, *Hemiacodon*, *Centetodon*, *Talpavus*, and *Entomacodon;* all represented by animals of small size. In the Miocene, the bones of Insectivores are comparatively abundant, and the genera best determined are *Ictops* and *Leptictis*. A few specimens only have been found in the Pliocene and Post-Pliocene, most of them related to the Moles. No extinct Insectivores are known from South America, and no member of the group exists there at present.

The *Carnivora*, or true flesh-eating animals, are an old type, well represented in the Eocene, and, as might be expected, these early forms are much less specialized than the living species. In the Coryphodon beds, the genus *Limnocyon*, allied to the *Pterodon* of the European Eocene, is abundant. Another genus, apparently distinct, is *Prototomus*, and several others have been named from fragmentary fossils. In the middle Eocene, Carnivores were still more numerous, and many genera have been discovered. One of these, *Limnofelis*, was nearly as large as a lion, and apparently allied to the cats, although the typical *Felidæ* seem not yet to have been differentiated. Another Carnivore of nearly equal size was *Orocyon*, which had short massive jaws and broad teeth. *Dromocyon* and *Mesonyx* were large animals, allied to *Hyænodon*. The teeth were narrow, and the jaws long and slender. Among the smaller Carnivores were, *Vulpavus*, *Viverravus*, *Sinopa*, *Thinocyon*, and *Ziphacodon*.

In our Western Miocene, Carnivores are abundant, and make an approach to modern types. The *Felidæ* are well represented, the most interesting genus being *Machairodus*, which is not uncommon in the Oreodon beds on both sides of the Rocky Mountains. An allied genus is *Dinictis*, and several smaller Cats are known from about the same horizon. The *Canidæ* are represented by *Amphicyon*, a European genus, and

by several species of *Canis*, or a very nearly allied form. The peculiar genus *Hyænodon*, found also in Europe, and the type of a distinct family, is abundant in the Miocene east of the Rocky Mountains, but has not yet been found on the Pacific Coast. In the Pliocene of both regions, the *Canidæ* are numerous, and all apparently belong to the existing genus *Canis*. The genus *Machairodus* is still the dominant form of the Cats, which are abundant, and for the most part belong to the genus *Felis*. The extinct *Leptarctus* is supposed to belong to the *Ursidæ*, and if so, is the oldest American representative of this family. In the Post-Pliocene, the extinct *Felidæ* include species nearly as large as a lion, and smaller forms very similar to those still living. Bears, Raccoons and Weasels have also been found.

In the Pliocene of South America, *Machairodus* represents the *Felidæ*, while the genera *Arctotherium* and *Hyænarctus* belong to the Bear family. Species of *Mustela* and *Canis* have also been found. In the caves of Brazil, the fauna of which is regarded as Post-Pliocene, one species of *Machairodus* is known, and one of *Synœlurus*. *Canis* and *Icticyon*, still living in Brazil, and the extinct genus *Speothos*, represent the *Canidæ*. *Mephitis* and *Galictis*, among the Weasels, were also present, and with them species of *Nasua* and *Arctotherium*.

We come now to the highest group of Mammals, the Primates, which includes the Lemurs, the Apes, and Man. This order has a great antiquity, and even at the base of the Eocene we find it represented by several genera belonging to the lower forms of the group. In considering these interesting fossils, it is important to have in mind that the Lemurs, which are usually regarded as Primates, although at the bottom of the scale, are only found at the present day in Madagascar and the adjacent regions of the globe. All the American Monkeys, moreover, belong to one group, much above the Lemurs, while the Old World Apes are higher still, and most nearly approach Man.

In the lower Eocene of New Mexico, we find a few representatives of the earliest known Primates, and among them are the genera *Lemuravus* and *Limnotherium*, each the type of a distinct family. These genera became very abundant in the middle Eocene of the West, and with them are found many others, all however, included in the two families, *Lemuravidæ* and *Limnotheridæ*. *Lemuravus* appears to have been most nearly allied to the Lemurs, and is the most generalized form of the Primates yet discovered. It had forty-four teeth, forming a continuous series above and below. The brain was nearly smooth, and of moderate size. The skeleton most resembles that of the Lemurs. A nearly allied genus, belonging to the same family, is *Hyopsodus*. *Limnotherium* (*Tomitherium*) also is nearly related to the Lemurs, but shows some affin-

ities with the South American Marmosets. This genus had forty teeth. The brain was nearly smooth, and the cerebellum large, and placed mainly behind the cerebrum. The orbits are open behind, and the lachrymal foramen is outside the orbit. Other genera belonging to the *Limnotheridæ* are, *Notharctos*, *Hipposyus*, *Microsyops*, *Palæacodon*, *Thinolestes* and *Telmatolestes*. Besides these, *Antiacodon* (*Anaptomorphus*), *Bathrodon* and *Mesacodon* should probably be placed in the same group. In the Diplacodon Beds, or Upper Eocene, no remains of Primates have yet been detected, although they will doubtless be found there. All the Eocene Primates known from American strata are low generalized forms, with characters in the teeth, skeleton and feet that suggest relationships with the Carnivores, and even with the Ungulates. These resemblances have led palæontologists to refer some imperfect specimens to both these orders.

In the Miocene lake basins of the West, only a single species of the *Primates* has been identified with certainty. This was found in the Oreodon Beds of Nebraska, and belongs to the genus *Laopithecus*, apparently related both to the *Limnotheridæ* and to some existing South American Monkeys. In the Pliocene and Post-Pliocene of North America, no remains of Primates have yet been found.

In the Post-Pliocene deposits of the Brazilian caves, remains of Monkeys are numerous, and mainly belong to extinct species of *Callithrix*, *Cebus* and *Jacchus*, all living South American genera. Only one extinct genus, *Protopithecus*, which embraced animals of large size, has been found in this peculiar fauna.

It is a noteworthy fact, that no traces of any Anthropoid Apes, or indeed of any Old World Monkeys have yet been detected in America. Man, however, the highest of the Primates, has left his bones and his works from the Arctic Circle to Patagonia. Most of these specimens are clearly Post-Tertiary, although there is considerable evidence pointing to the existence of Man in our Pliocene. All the remains yet discovered belong to the well-marked genus *Homo*, and apparently to a single species, at present represented by the American Indian.

In this rapid review of Mammalian life in America, from its first known appearance in the Trias down to the present time, I have endeavored to state briefly the introduction and succession of the principal forms in each natural group. If time permitted, I might attempt the more difficult task of trying to indicate what relations these various groups may possibly bear to each other; what connection the ancient Mammals of this continent have with the corresponding forms of the Old World; and, most important of all, what real progress Mammalian life has here made since the beginning of the Eocene. As it is, I

can only say in summing up, that the Marsupials are clearly the remnants of a very ancient fauna, which occupied this continent millions of years ago, and from which the other Mammals were doubtless all derived, although the direct evidence of the transformation is wanting.

Although the Marsupials are nearly related to the still lower Monotremes, now living in the Australian Region, we have as yet no hint of the path by which these two groups became separated from the inferior vertebrates. Neither have we to-day much light as to the genetic connection existing between Marsupials and the placental Mammalia, although it is possible that the different orders of the latter had their origin each from a separate group of the Marsupials.

The presence, however, of undoubted Marsupials in our lower and middle Eocene, some of them related to the genus *Didelphys*, although remotely, is important evidence as to the introduction of these animals into America. Against this, their supposed absence in our Miocene and Pliocene can have but limited weight, when taken in connection with the fact that they flourished in the Post-Tertiary, and are still abundant. The evidence we now have is quite as strongly in favor of a migration of Marsupials from America to the Old World, as the reverse, which has been supposed by some naturalists. Possibly, as Huxley has suggested, both countries were peopled with these low mammals from a continent now submerged.

The Edentate mammals have long been a puzzle to zoologists, and up to the present time no clew to their affinities with other groups seems to have been detected. A comparison of the peculiar Eocene Mammals which I have called the *Tillodontia*, with the least specialized Edentates, brings to light many curious resemblances in the skull, teeth, skeleton and feet. These suggest relationship, at least, and possibly we may yet find here the key to the Edentate genealogy. At present, the Tillodonts are all from the lower and middle Eocene, while *Moropus*, the oldest Edentate genus, is found in the middle Miocene, and one species in the lower Pliocene.

The Edentates have been usually regarded as an American type, but the few living forms in Africa, and the Tertiary species in Europe, the oldest known, have made the land of their nativity uncertain. I have already given you some reasons for believing that the Edentates had their first home in North America, and migrated thence to the southern portion of the continent. This movement could not have taken place in the Miocene period, as the Isthmus of Darien was then submerged; but near the close of the Tertiary, the elevation of this region left a much broader strip of land than now exists there, and over this, the Edentates and other

mammals made their way, perhaps urged on by the increasing cold of the glacial winters. The evidence to-day is strongly in favor of such a southern migration. This, however, leaves the Old World Edentates, fossil and recent, unaccounted for; but I believe the solution of this problem is essentially the same, namely: a migration from North America. The Miocene representatives of this group, which I have recently obtained in Oregon, are older than any known in Europe, and, strangely enough, are more like the latter and the existing African types than like any of our living species. If, now, we bear in mind that an elevation of only 180 feet would, as has been said, close Behring's Straits, and give a road thirty miles wide from America to Asia, we can easily see how this migration might have taken place. That such a Tertiary bridge did exist, we have much independent testimony, and the known facts all point to extensive migrations of animals over it.

The *Cetacea* are connected with the marine Carnivores through the genus *Zeuglodon*, as Huxley has shown, and the points of resemblance are so marked that the affinity cannot be doubted. That the connection was a direct one, however, is hardly probable, since the diminutive brain, large number of simple teeth, and reduced limbs in the Whales, all indicate them to be an old type, which doubtless branched off from the more primitive stock leading to the Carnivores. Our American extinct Cetaceans, when carefully investigated, promise to throw much light upon the pedigree of these strange mammals. As most of the known forms were probably marine, their distribution is of little service in determining their origin.

That the Sirenians are allied to the Ungulates is now generally admitted by anatomists, and the separation of the existing species in distant localities suggests that they are the remnants of an extensive group, once widely distributed. The large number of teeth in some forms, the reduced limbs and other characters, point back to an ancestry near that of the earliest ungulates. The gradual loss of teeth in the specialized members of this group, and in the Cetaceans, is quite parallel with the same change in Edentates, as well as in Pterodactyls and Birds.

The Ungulates are so distinct from other groups that they must be one of the oldest natural divisions of mammals, and they probably originated from some herbivorous marsupial. Their large size, and great numbers during Tertiary and Post-tertiary time, render them most valuable in tracing migrations induced by climate, as well as in showing the changes of structure which such a contest for existence may produce.

In the review of the extinct Ungulates, I have endeavored to show that quite a number of genera usually supposed to

belong originally to the Old World are in reality true American types. Among these were the Horse, Rhinoceros, and Tapir, all the existing odd-toed Ungulates, and besides these the Camel, Pig, and Deer. All these I believe, and many others, went to Asia from our North West Coast. It must, for the present, remain an open question whether we may not fairly claim the *Bovidæ*, and even the *Proboscidea*, since both occur in our strata at about the same horizon as on the other continent. On this point there is some confusion, at least in names. The Himalayan deposits called Upper Miocene, and so rich in Proboscideans, indicate in their entire fauna that they are more recent than our Niobrara River beds, which, for apparently good reasons, we regard as Lower Pliocene. The latter appear to be about the same horizon as the Pikermi deposits in Greece, also regarded as Miocene. Believing, however, that we have here a more complete Tertiary series, and a better standard for comparison of faunas, I have preferred to retain the names already applied to our divisions, until the strata of the two continents are more satisfactorily coördinated.

The extinct Rodents, Bats, and Insectivores of America, although offering many suggestive hints as to their relationship with other groups, and their various migrations, cannot now be fully discussed. There is little doubt, however, that the Rodents are a New World type, and, according to present evidence, they probably had their origin in North America. The resemblance in so many respects of this order to the Proboscideans is a striking fact, not yet explained by the imperfectly known genealogy of either group.

The Carnivores, too, I must pass by, except to call attention to a few special forms which accompanied the migrations of other groups. One of these is *Machairodus*, the saber-toothed Tiger, which flourished in our Miocene and Pliocene, and followed the huge Edentates to South America, and the Ungulates across Asia to Europe. With this genus went *Hyænodon*, and some typical Wolves and Cats, but the Bears came the other way with the Antelopes. That the Gazelle, Giraffe, Hippopotamus, Hyaena and other African types, once abundant in Asia, did not come, is doubtless because the Miocene bridge was submerged before they reached it.

The Edentates, in their southern migration, were probably accompanied by the Horse, Tapir and Rhinoceros, although no remains of the last have yet been found south of Mexico. The Mastodon, Elephant, Llama, Deer, Peccary, and other mammals, followed the same path. Why the Mastodon, Elephant, Rhinoceros, and especially the Horse, should have been selected with the huge Edentates for extinction, and the other Ungulates left, is at present a mystery, which their somewhat larger size hardly explains.

The relations of the American Primates, extinct and recent, to those of the other hemisphere, offer an inviting topic, but it is not in my present province to discuss them in their most suggestive phases. As we have here the oldest and most generalized members of the group, so far as now known, we may justly claim America for the birth-place of the order. That the development did not continue here until it culminated in Man, was due to causes which at present we can only surmise, although the genealogy of other surviving groups gives some data toward a solution. Why the old world Apes, when differentiated, did not come to the land of their earlier ancestry, is readily explained by the then intervening oceans, which likewise were a barrier to the return of the Horse and Rhinoceros.

Man, however, came; doubtless first across Behring's Straits; and at his advent became part of our fauna, as a mammal and primate. In these relations alone, it is my purpose here to treat him. The evidence, as it stands to-day, although not conclusive, seems to place the first appearance of Man in this country in the Pliocene, and the best proof of this has been found on the Pacific coast. During several visits to that region, many facts were brought to my knowledge which render this more than probable. Man at this time was a savage, and was doubtless forced by the great volcanic outbreaks to continue his migration. This was at first to the south, since mountain chains were barriers on the east. As the native Horses of America were now all extinct, and as the early man did not bring the old world animal with him, his migrations were slow. I believe, moreover, that his slow progress towards civilization was in no small degree due to this same cause, the absence of the Horse.

It is far from my intention to add to the many theories extant in regard to the early civilizations in this country, and their connections with the primitive inhabitants, or the later Indians, but two or three facts have recently come to my knowledge which I think worth mentioning in this connection. On the Columbia River, I have found evidence of the former existence of inhabitants much superior to the Indians at present there, and of which no tradition remains. Among many stone carvings which I saw there, were a number of heads which so strongly resemble those of Apes, that the likeness at once suggests itself. Whence came these sculptures, and by whom were they made? Another fact that has interested me very much is the strong resemblance between the skulls of the typical Mound-builders of the Mississippi Valley and those of the Pueblo Indians. I had long been familiar with the former, and when I recently saw the latter, it required the positive

assurance of a friend who had himself collected them in New Mexico, to convince me that they were not from the mounds. A third fact, and I leave Man to the Archæologists, on whose province I am even now trenching. In a large collection of Mound-builders' pottery, over a thousand specimens, which I have recently examined with some care, I found many pieces of elaborate workmanship so nearly like the ancient water-jars from Peru, that no one could fairly doubt that some intercourse had taken place between the widely separated people that made them.

The oldest known remains of Man on this continent differ in no important characters from the bones of the typical Indian, although in some minor details they indicate a much more primitive race. These early remains, some of which are true fossils, resemble much more closely the corresponding parts of the highest Old World Apes, than do the latter our Tertiary Primates, or even the recent American Monkeys. Various living and fossil forms of old world Primates fill up essentially the latter gap. The lesser gap between the primitive Man of America and the Anthropoid Apes is partially closed by still lower forms of men, and doubtless also by higher Apes, now extinct. Analogy, and many facts as well, indicate that this gap was smaller in the past. It certainly is becoming wider now with every generation, for the lowest races of men will soon become extinct, like the Tasmanians, and the highest Apes cannot long survive. Hence the intermediate forms of the past, if any there were, become of still greater importance. For such missing links, we must look to the caves and later Tertiary of Africa, which I regard as now the most promising field for exploration in the Old World. America, even in the Tropics, can promise no such inducements to ambitious explorers. We have, however, an equally important field, if less attractive, in the Cretaceous Mammals, which must have left their remains somewhere on this continent. In these two directions, as I believe, lie the most important future discoveries in Palæontology.

As a cause for many changes of structure in mammals during the Tertiary and Post-Tertiary, I regard, as the most potent, *Natural Selection*, in the broad sense in which that term is now used by American evolutionists. Under this head, I include not merely a Malthusian struggle for life among the animals themselves, but the equally important contest with the elements, and all surrounding nature. By changes in the environment, migrations are enforced, slowly in some cases, rapidly in others, and with change of locality must come adaptation to new conditions, or extinction. The life-history of Tertiary mammals illustrates this principle at every stage, and no other explanation meets the facts.

The real progress of mammalian life in America, from the beginning of the Tertiary to the present, is well illustrated by the Brain-growth, in which we have the key to many other changes. The earliest known Tertiary mammals all had very small brains, and in some forms this organ was proportionally less than in certain Reptiles. There was a gradual increase in the size of the brain during this period, and it is interesting to find that this growth was mainly confined to the cerebral hemispheres, or higher portion of the brain. In most groups of mammals, the brain has gradually become more convoluted, and thus increased in quality, as well as quantity. In some, also, the cerebellum, and olfactory lobes, the lower parts of the brain, have even diminished in size. In the long struggle for existence during Tertiary time, the big brains won, then as now; and the increasing power thus gained rendered useless many structures inherited from primitive ancestors, but no longer adapted to new conditions.

Another of the interesting changes in mammals during Tertiary time was in the teeth, which were gradually modified with other parts of the structure. The primitive form of tooth was clearly a cone, and all others are derived from this. All classes of vertebrates below mammals, namely, Fishes, Amphibians, Reptiles, and Birds, have conical teeth, if any, or some simple modification of this form. The Edentates and Cetaceans with teeth retain this type, except the Zeuglodonts, which approach the dentition of aquatic Carnivores. In the higher mammals, the incisors and canines retain the conical shape, and the premolars have only in part been transformed. The latter gradually change to the more complicated molar pattern, and hence are not reduced molars, but transition forms from the cone to more complex types. Most of the early Tertiary mammals had forty-four teeth, and in the oldest forms the premolars were all unlike the molars; while the crowns were short, covered with enamel, and without cement. Each stage of progress in the differentiation of the animal was, as a rule, marked by a change in the teeth; one of the most common being the transfer, in form at least, of a premolar to the molar series, and a gradual lengthening of the crown. Hence, it is often easy to decide from a fragment of a jaw, to what horizon of the Tertiary it belongs. The fossil Horses of this period, for example, gained a grinding tooth, for each toe they lost, one in each epoch. In the single-toed existing horses, all the premolars are like the molars, and the process is at an end. Other dental transformations are of equal interest, but this illustration must suffice.

The changes in the limbs and feet of mammals during the same period were quite as marked. The foot of the primitive mammal was doubtless plantigrade, and certainly five-toed.

Many of the early Tertiary forms show this feature, which is still seen in some existing forms. This generalized foot became modified by a gradual loss of the outer toes, and increase in size of the central ones; the reduction proceeding according to systematic methods, differing in each group. Corresponding changes took place in the limb bones. One result was a great increase in speed, as the power was applied so as to act only in the plane of motion. The best effect of this specialization is seen to-day in the Horse and Antelope, each representing a distinct group of Ungulates, with five-toed ancestors.

If the history of American Mammals as I have briefly sketched it, seems as a whole incomplete, and unsatisfactory, we must remember that the genealogical tree of this class has its trunk and larger limbs concealed beneath the *débris* of Mesozoic time, while its roots doubtless strike so deeply into the Paleozoic that for the present they are lost. A decade or two hence, we shall probably know something of the mammalian fauna of the Cretaceous, and the earlier lineage of our existing mammals can then be traced with more certainty.

The results I have presented to you are mainly derived from personal observation; and since a large part of the higher vertebrate remains found in this country have passed through my hands, I am willing to assume full responsibility for my presentation of the subject.

For our present knowledge of the extinct Mammals, Birds and Reptiles of North America, science is especially indebted to Leidy, whose careful, conscientious work has laid a secure foundation for our vertebrate palæontology. The energy of Cope has brought to notice many strange forms, and greatly enlarged our literature. Agassiz, Owen, Wyman, Baird, Hitchcock, Deane, Emmons, Lea, Allen, Gibbes, Jefferson, DeKay, and Harlan, deserve honorable mention in the history of this branch of science. The South American extinct vertebrates have been described by Lund, Owen, Burmeister, Gervais, Huxley, Flower, Desmarest, Aymard, Pictet, and Nodot. Darwin and Wallace have likewise contributed valuable information on this subject, as they have on nearly all forms of life.

In this long history of ancient life I have said nothing of what Life itself really is. And for the best of reasons, because I know nothing. Here at present our ignorance is dense, and yet we need not despair. Light, Heat, Electricity, and Magnetism, Chemical Affinity and Motion, are now considered different forms of the same force; and the opinion is rapidly gaining ground that Life, or vital force, is only another phase of the same power. Possibly the great mystery of Life may thus be solved, but whether it be or not, a true faith in Science knows no limit to its search for Truth.

Art. XLIII.—*Note on the Helderberg Formation of Bernardston, Massachusetts, and Vernon, Vermont;* by James D. Dana.

In examinations of the Bernardston Helderberg formation which were the basis of my former paper "On the Rocks of the Helderberg era in the Valley of the Connecticut"* my main purpose was lithological—that is, to ascertain and point out the kinds of crystalline rocks that were comprised within terranes of Helderberg (later Upper Silurian) age. The conformable position of the Bernardston limestone beneath strata of quartzyte and slate, first made known by Professor Edward Hitchcock,† I found to be, as I thought, a fact; and from there I traced the quartzyte at intervals, along with the slate—a peculiar mica slate easily distinguished by the minute garnets which gave its layers a pimpled surface, and the small crystals of mica set transversely to the lamination—over the country, to South Vernon in Vermont; and announced in my paper that the Helderberg formation included, besides the quartzyte and mica slate, beds of compact green hornblende rock, a rock of the composition of syenyte, staurolitic mica slate, coarse mica schist, whitish and grayish quartzose gneiss, and all stages of passage between quartzyte and gneiss.

Recently, Professor C. H. Hitchcock, in the Second Volume of his Report on the Geology of New Hampshire,‡ and more briefly in a note in this Journal,§ has suggested that the order of stratification at the limestone locality is not the true order; that the rocks may be "in an inverted position:" that the limestone stratum may have *overlaid* both the other formations, that is, the quartzyte and mica slate;‖ that "the limestone occupies a small valley in the quartzyte."¶ Having, through this supposition, made the limestone the newest of the formations, he concludes, further, that the mica slate, now lying over it, is not necessarily Helderberg; that the hornblende rocks and gneiss of Vernon are not necessarily of the Helderberg series,** and neither the staurolitic slate; that a long period

* This Journal, III, vi, 339.

† Report on the Geology, etc. of Massachusetts, by E. Hitchcock, 8vo, 1833, p. 295; Report of Amer. Assoc. for 1851, p. 299; Report Geol. of Vermont, 2 vols. 4to, 1861, p. 447. This last notice was prepared in conjunction with Mr. C. H. Hitchcock. It gives a section representing the limestone dipping beneath quartzyte and slate.

‡ Page 428 and beyond, 1877.

§ Vol. xiii, page 313, April, 1877.

‖ Ibid.

¶ Report New Hampshire, vol. ii, p. 455.

** It should be added here that the volume of the N. Hampshire Geological Report referred to conveys on an earlier page (p. 18), a different opinion as to the limits of the Helderberg, where it is stated that the Connecticut Valley Helderberg series consists of several thousand feet in thickness of quartzytes, limestones, slates, conglomerates, sandstones, flags, and probably hornblende schists.

intervened between the deposition of the hornblendic stratum and quartzyte.

While thus dissenting from my conclusions, Professor Hitchcock adopts my suggestion that the garnetiferous mica slate which overlies the quartzyte and limestone at the Bernardston limestone locality is identical with the Coös slate of the Connecticut Valley in all its characters and age, and hence that *if* the former should turn out after all to be Helderberg, the Coös formation (which extends up the valley to Canada, according to Professor Hitchcock) is also Helderberg or later Upper Silurian.

These differences of opinion, and the wide bearing of the facts on New England geology have led me to revisit the place and examine it anew. In my former paper I closed by stating my intention, another season, to study the stratigraphical details of the region, and trace out the limits or range of the formations southward along the Connecticut Valley. But other geological work in Western and Southern New England, and on the islands off its southern coast, have since occupied such leisure time as I could command. In my recent visit to Bernardston I was accompanied by Professor B. K. Emerson, of Amherst College; and it is a great satisfaction to know that he will give the whole subject a careful and thorough study, and connect it with a general geological survey of Central and Western Massachusetts—work for which he is eminently fitted.

To facilitate explanations I repeat the section of the strata at the Bernardston locality before published, with one correction. No. 3, the blocked area, represents the stratum of Crinoidal limestone; Nos. 1 and 4, dotted areas, an underlying and an overlying stratum of quartzyte; and Nos. 2 and 5, finely lined areas, an underlying and an overlying stratum of

garnetiferous mica slate. The succession and position are the same as in the section by Professor Hitchcock in the Vermont Geological Report, excepting the omission here of a layer of slate immediately *over* the limestone.

The conclusions which the facts appear to me to sustain, in opposition to those set forth by Professor C. H. Hitchcock in the New Hampshire Report of 1877, but mostly in agreement with Mr. C. H. Hitchcock of the Vermont Report* (p. 598) of 1861—are the following:

*The Vermont Report makes no mention, in the chapter on the Bernardston limestone (p. 447), of the hornblende rocks, gneiss, etc., of the adjoining region on the east. But on page 598, in an account of "Section I," extending across the

1. That the quartzyte is Helderberg as much as the limestone.
2. That the garnetiferous mica slate is equally Helderberg.
3. That the limestone is a local deposit between the other members of the Helderberg formation.
4. That hornblende rocks, staurolitic slate, mica schist and gneiss of the adjoining region on the east and northeast are of one and the same geological formation.

1. *The Quartzyte is of the Helderberg formation.* The overlying quartzyte (No. 4) besides occurring in large outcrops over the hill-side, *constitutes the upper two to four feet* of the vertical section exposed in a portion of the limestone quarry. This alone proves its conformable position and close relation to the limestone. But further, while this overlying quartzyte is in part very compact and solid, some portions are very cellular from the removal of calcareous matter and pyrite, and also from the removal of fossils. The first of the fossils was found by Professor Emerson, while we were together, and was a cast of a *Pentamerus;* and both of us afterward obtained other specimens. The casts were too imperfect for a decision as to the species; but they appear to show that it was nearly equal in height and breadth, and without costæ, which are characteristics of the *P. pseudo-galeatus*, a Lower Helderberg species. Besides these brachiopods, there were in the same layers of the quartzyte numerous fragments of *crinoidal stems*, mostly of small species. Some of the laminæ of this quartzyte have between them mica in scales, so as to look in a surface view like mica schist.

The fact that there is conformability between the limestone and quartzyte is hence beyond question. And it is equally certain that, overturned or not, the quartzyte belongs to the same

south extremity of the State near the Massachusetts boundary, Mr. C. H. Hitchcock describes the hornblende rocks of Vernon and Bernardston as associated with gneiss and mica schists; states that the mica schist west of South Vernon contains chiastolite [staurolite?]; speaks of the gneiss as graduating insensibly into the quartz rock, as in some places difficult to be distinguished from granite, as also "invariably resting upon the quartz rock" and hence "newer" than it; as, therefore, probably of the Upper Helderberg age, like the Bernardston limestone (Hall's first determination), which rests on the same quartz rock; thus making the whole series Upper Helderberg. The unconformability of the quartz rock series on the clay slate is also recognized.

If these were still his views, excepting the change of Upper Helderberg to Lower Helderberg, we should be in close agreement. In my arguments above, I am in fact sustaining Mr. C. H. Hitchcock of 1861, against Professor C. H. Hitchcock of 1877) whose later conclusions have been influenced by his faith in the lithological test of geological age, and his unbelief in the existence of gneiss-like metamorphic rocks of later date than Cambrian.

The suspicion that C. H. Hitchcock may not have been the author of the notes on Section I is apparently set aside by the heading of the Chapter, "Notes on the Sections, by C. H. Hitchcock," and the absence of any statement that the notes on Section I were prepared by any other person.

era with the crinoidal limestone; for the former really graduates into the latter as its calcareous matter and fossils show.

2. *The garnetiferous mica slate is of the Helderberg formation.*—This is demonstrated by the existence of a stratum of garnetiferous mica slate (No. 2, in the section, p. 380,) *beneath* the limestone as well as one (No. 5) above. This inferior mica slate wants the little disseminated crystals of mica common in the other; but it is pimpled with garnets like that. The line of outcrops extends for several rods, and runs along within a few yards of the limestone, at the nearest point hardly a yard of earth intervening; and the strike and dip throughout correspond with that of the limestone adjoining. Having garnetiferous mica slate below the limestone as well as above, and the three strata conformable in dip, there can be no reasonable doubt that all are of one formation. The limestone stratum is so placed with reference to those above and below that it could not have been originally at the top, and the newest of the series. Whatever faulting or inversion be supposed, it must have had originally, as it has now, an overlying and an underlying mica slate.

3. *The limestone a local deposit in the Helderberg formation.*—The fact that the limestone has not been observed elsewhere in the region is no evidence of independent and later formation. It is plainly an isolated bed, of limited lateral extent, *like those that are so common in the widely spread "Calciferous mica schist" of the Connecticut Valley.* The fact that it is a wedge-shaped mass thus isolated is evident; for just north of the main quarry it soon thins out, (together with the thin underlying stratum of mica slate) through the approach and junction of the overlying and underlying quartzyte. Fossils, if found in any of the many isolated calcareous deposits in the "Calciferous mica schist," would be regarded as showing the age of the schist; and so it should be here.

Professor Hitchcock says that if the Coös slate is Helderberg, the Calciferous mica schist is unquestionably so too. Admitting this to be true, the parallelism between the Bernardston limestone and the isolated calcareous deposits in the schist becomes complete.*

4. *The hornblende rocks, staurolitic slate, mica schist and associated gneiss are of the Helderberg formation.*—As limestone has been found in the region only at the one locality in Bernardston, the evidence of equivalence has to be derived from the distribution of its associated rocks. This evidence, east and northeast of the Bernardston village-plain, is as follows:

(1.) The same garnetiferous mica slate with disseminated brown mica crystals set transversely that occurs associated

* My knowledge of the rock formations of Western Vermont is not sufficient to warrant an independent opinion with regard to the "Calciferous mica schist."

with quartzyte at the Bernardston locality on the west side of the Bernardston plain occurs associated with quartzyte at different points between Bernardston and Vernon. It sometimes dips beneath quartzyte and sometimes overlies it.

(2.) Outcrops of the quartzyte and the peculiar Bernardston mica slate together appear east and northeast of Bernardston within one to one and a half miles of the Crinoidal limestone locality (the intervening flat valley being under drift and alluvium), and at intervals beyond, to Vernon, with the same aspect and conformable superposition as at the limestone locality.

(3.) In the same region, hornblende rocks, staurolitic slate, gneiss and mica schist occur in alternating beds with the Bernardston mica slate and quartzyte.

A mile and a half east of Bernardston,* the Bernardston mica slate occurs in alternating beds with the hornblende rock, —a gray-green compact rock, not schistose—with so obvious junctions that the alternation cannot be questioned. The hornblende rock (1) dips beneath (2) mica slate; this beneath (3) hornblende rock; and the last beneath (4) mica slate again. Whether there is a fault between 2 and 3 is not certain; but it is unquestionable that 1 and 2, and 3 and 4 are strictly conformable. Part of the hornblende rock is speckled white with quartzyte and feldspar and is like a quartzytic syenite in constitution, though unlike true syenyte in aspect.

Again: a mile to the north of the last-mentioned locality and less than a mile and a half northeast of the Bernardston limestone locality, the same peculiar mica slate may be seen, dipping at a small angle beneath a stratum of quartzyte, the conformability, as in other cases in the region, unquestionable. Now this quartzyte stratum, while in part quartzyte, is partly a tough micaceous rock consisting chiefly of aggregated scales of brown mica, but with some hornblende and quartz.

Again: the Bernardston slate of the locality just mentioned extends eastward and is the same stratum, as well as the same kind of slate, with that of Purple's quarry, described in my former paper; which slate contains occasional crystals of *staurolite.* Hence the Bernardston slate which alternates with quartzyte is in some places a *staurolitic slate.* Another place, farther east, is mentioned in my former paper where the slate is abundantly staurolitic.

Again: in Vernon, four to five miles northwest of South Vernon, where the quartzyte is largely exposed to view, one of the quartzyte knolls consists partly of mica rock like that above described, made up mainly of aggregated scales of brown mica but containing distributed through it some quartz and

* For the position of this locality see my former paper.

hornblende. In other outcrops in the field adjoining, the rock is mostly true quartzyte, but partly a green compact hornblende rock, with insensible gradations between it and the quartzyte.

Again: at South Vernon, over the slopes nearly west of the hotel, there occur—first quartzyte, but with it, and graduating into it, the compact green hornblende rock; then, high up the slope, a coarse garnetiferous mica schist consisting mainly of brown mica, which is nothing but a coarse form of the Bernardston slate; and in this mica schist there are hornblendic layers; and some beds which consist of a quartzytic syenyte, though with the hornblende grains in slender crystals.

Again: between Vernon Center and South Vernon, there are outcrops showing the transition between the quartzyte and a quartzytic gneiss. The gneiss has the aspect of any ordinary light-colored thick-bedded gneiss. But it is all quartzytic, and in part very largely so.

Besides this light-colored quartzytic gneiss, there is also, north of South Vernon, quartzytic syenite, a whitish rock containing small grains of greenish hornblende, rather sparsely disseminated, without mica, and making a handsome rock which might at first be taken for a white granite.

5. *Conclusion.*—Thus, the region affords examples (1) of the *interstratification* of the quartzyte and Bernardston mica slate, with a green massive hornblende rock; with a syenytic rock; with gneiss; and with coarse mica schist; (2) of *transitions* of the Bernardston mica slate into staurolitic slate and mica schist; and (3) of *transitions* of the quartzyte into (*a*) micaceous quartzyte; (*b*) a tough quartzytic mica rock, more or less hornblendic; (*c*) quartzytic gneiss often granitoid: (4) green hornblende rock; and (5) syenyte, besides various intermediate forms. For some other examples of these transitions I refer to my former paper.

The demonstration is certainly complete that whatever the age of the quartzyte and the associated Bernardston mica slate, the same is the age of the rocks above mentioned; and that the fossils of the Bernardston locality decide the age approximately for the series; and finally, that all are of the Helderberg formation or later Upper Silurian, if that is true of the Crinoidal limestone.

6. *Lithological characteristics.*—In using the lithological test of geological age it must hence be noted that the following may be rocks of metamorphic Upper Silurian formations: mica slate and schist; staurolitic mica slate; hornblendic rocks, varying from a kind consisting mainly of green hornblende to a quartzytic syenyte, and hornblendic quartzyte; quartzytic gneiss; true gneiss; micaceous quartzyte; quartzyte.

The minerals included among the abundant metamorphic species are: brown and white mica, the former much the most

common; staurolite; green and black hornblende; orthoclase; garnet; along with pyrite, magnetite, and granular limestone.

The mica slate and schist and the staurolitic mica slate are not distinguishable from kinds that are of earlier age.

The hornblende rocks are peculiar. Those which are made mainly of hornblende have a dark green color, and are massive, often indistinct in bedding instead of schistose and much jointed. The larger part consist of minute interlaced fibers; with sometimes whitish spots giving the rock a porphyritic aspect, which spots consist of quartzyte combined usually with grains of orthclase. Thin slices in polarized light under the microscope are beautiful objects. A cleavable granular variety occurs but is less common. Coarser kinds have the hornblende in oblong pointed crystals imbedded in fine grained quartzyte or quartzyte and orthoclase.

The whitish quartzytic syenite mentioned on the preceding page is peculiar in having a very fine grain; the hornblende dark green in color, and generally in oblong grains; and the whiter portions of the rock of an opaque white color and made up mostly of grains of orthoclase. In a thin slice, these whiter portions lie between others that are pellucid and consist of quartz grains with few of feldspar.

The gneiss also is peculiar. It generally consists very largely of grains of quartz, even where looking to the eye like a true gneiss. The mica is almost solely the brown kind and is like that of the mica slate, though often seeming to have as little elasticity as chlorite; and the regular disposition of the spots of mica, give to the most quartzytic varieties a strikingly gneiss-like look. Professor Hitchcock refers the rock to the Bethlehem gneiss. But "the most characteristic of the rocks comprising this formation," he says, speaking of the Bethlehem gneiss, "is a reddish granitic gneiss, the flesh-colored orthoclase predominating, with chloritic or some hydro-micaceous mineral in place of ordinary mica, and quartz in variable proportions" (Report, p. 105); and to such a rock it has little resemblance. Yet, it is to be admitted that there is nothing in the amount of orthoclase in characteristic "Bethlehem gneiss" which renders connection with a Helderberg formation improbable.

The quartzyte in some places—as two miles west of South Vernon,—contains much pearly mica (hydrous mica?); a weathered surface of such a specimen shows that the rock consists mainly of quartz. In other places the quartzyte is marked with dark-gray and blackish lines where the mica is not distinguishable without a glass. All of it indicates by its fineness of texture, and sometimes even flinty aspect, that the quartz sand of which it was made was very finely comminuted, and not coarse like that from which the Green Mountain

quartzyte was made; and hence that the region, when the deposition took place, was not the border of the open sea.

7. *Origin of the Rocks.*—To understand the rocks of this Helderberg region, it must be borne in mind: that quartzyte beds in their original state, that is, beds of quartz sand, may have been formed at different times in the course of the era, owing to changes of level or of currents; that the sand beds—like those of any other era and of the present time—would, in many places, have had more or less earthy material (ground-up crystalline rock) with the quartz sand, so that metamorphism could not make pure quartzyte out of it, but might make a micaceous or gneissoid quartzyte, or a quartzytic gneiss, according to the nature of the earthy material present; that while sand-beds were formed where the currents were rapid enough for the purpose, mud-beds would have formed where the waters were more quiet, as now on all coasts (for sand-beds never exist along shores without cotemporaneous mud-beds within a distance that is not great); and that from these mud-beds, or beds of finely triturated rocks, the mica slate, mica schist, or mica rock, and the hornblende rocks would have been produced. The existence of some potash and alumina in the triturated rock or mud (both ingredients of orthoclase) would have favored the formation of brown mica (biotite) by metamorphism, while the presence of lime or rather a calcium compound, that of hornblende: magnesia and iron being in about the same proportion in the hornblende as in the mica. Analyses of average biotite and dark green hornblende afford:

	Biotite.	Hornblende.
Silica	40	45
Alumina	18	10–12
Iron protoxide Iron sesquioxide	10	10
Magnesia	22	20
Lime	--	14
Potash	10	--

The magnesia would have come from the trituration of such older rocks as are made partly or wholly of minerals containing it; of which minerals, hornblende and biotite are the most common.

Admitting the Coös formation of Professor Hitchcock, and the Calciferous mica schist adjoining it, to be of the same formation with the mica slate, quartzyte, and hornblende rocks of the Bernardston and Vernon region, which Professor H. states to be a fact, this Helderberg formation stretches northward beyond the boundary of New England, with a breadth along the Connecticut Valley of fifteen to thirty miles or more:

breadth enough where narrowest—as at Bernardston—for a clear sea good for growing corals and crinoids. Whether Professor Hitchcock's Lisbon and Lyman groups, which he refers to the Huronian, are not to be included, remains to be ascertained, as indicated on page 317 of this volume. Adding them, it would follow that the Connecticut bay or channel of the Helderberg era covered a large part of Northern New Hampshire, and was connected with a great area in Maine marked off by the occurrence of Helderberg and Devonian fossils.

ART. XLIV.—*History of Cavern Exploration in Devonshire, England;* by W. PENGELLY, F.R.S., F.G.S., President of the Geological Section of the British Association at Plymouth.

[Continued from page 308.]

Brixham Cavern.—Early in 1858 an unsuspected cavern was broken into by quarrymen at the northwestern angle of Windmill Hill at Brixham, at a point seventy-five feet above the surface of the street, almost vertically below, and 100 feet above mean tide. On being found to contain bones, a lease in it was secured for the Geological Society of London, who appointed a committee of their members to undertake its exploration; funds were voted by the Royal Society, and supplemented by private subscriptions; the conduct of the investigation was intrusted to Mr. Prestwich and myself; and the work, under my superintendance, as the only resident member of the committee, was begun in July, 1858, and completed at midsummer, 1859.

The cavern, comprised within a space of 135 feet from north to south, and 100 from east to west, consisted of a series of tunnel galleries from six to eight feet in greatest width, and ten to fourteen feet in height, with two small chambers and five external entrances.

The deposits, in descending order, were:—

1st, or uppermost; a floor of stalagmite, from a few inches to a foot thick, and continuous over very considerable areas, but not throughout the entire cavern.

2d. A mass of small angular fragments of limestone, cemented into a firm concrete with carbonate of lime, commenced at the principal entrance, which it completely filled, and whence it extended thirty-four feet only. It was termed the *first bed.*

3d. A layer of blackish matter, about twelve feet long, and nowhere more than a foot thick, occurred immediately beneath the first bed, and was designated the *second bed.*

4th. A red, tenacious, clayey loam, containing a large number of angular and subangular fragments of limestone, varying from very small bits to blocks a ton in weight, made up the *third bed.* Pebbles of trap, quartz and limestone were somewhat prevalent, whilst nodules of brown hematite and blocks of stalagmite were occasionally met with in it. The usual depth of the bed was from two to four feet, but this was exceeded by four or five feet in two localities.

5th. The third bed lay immediately on an accumulation of pebbles of quartz, greenstone, grit and limestone, mixed with small fragments of shale. The depth of this, known as the *fourth* or *gravel bed*, was undetermined; for, excepting a few feet only, the limestone bottom was nowhere reached. There is abundant evidence that this bed, as well as a stalagmitic floor which had covered it, had been partially broken up and dislodged before the introduction of the third bed.

Organic remains were found in the stalagmitic floor and in each of the beds beneath it, with the exception of the second only; but as ninety-five per cent of the whole series occurred in the third, this was not unfrequently termed the *bone bed.*

The mammals represented in the stalagmite were bear, reindeer, *Rhinoceros tichorhinus*, mammoth, and cave lion.

The first bed yielded bear and fox only.

In the third bed were found relics of mammoth, *Rhinoceros tichorhinus*, horse, *Bos primigenius*, *B. longifrons*, red deer, reindeer, roebuck, cave lion, cave hyæna, cave bear, grizzly bear, brown bear, fox, hare, rabbit, *Lagomys spelæus*, water-vole, shrew, polecat and weasel.

The only remains met with in the fourth bed were those of bear, horse, ox and mammoth.

The human industrial remains exhumed in the cavern were flint implements and a hammer-stone, and occurred in the third and fourth beds only. The pieces of flint met with were thirty-six in number. Of these, fifteen are held to show evidence of having been artificially worked, in nine the workmanship is rude or doubtful, four have been mislaid, and the remainder are believed not to have been worked at all (see Phil. Trans., vol. clxiii, 1873, pp. 561, 562). Of the undoubted tools, eleven were found in the third and four in the fourth bed. Two of those yielded by the third bed, found forty feet apart, in two distinct but adjacent galleries, and one a month before the other, proved to be parts of one and the same *nodule*-tool; and I have little or no doubt that it had been washed out of the fourth bed and re-deposited in the third.

The hammer-stone was a quartzite pebble, found in the upper portion of the fourth bed, and bore distinct marks of the use to which it had been applied.

Speaking of the discovery of the tools just mentioned, Mr. Prestwich said in 1859:—"It was not until I had myself witnessed the conditions under which flint implements had been found at Brixham, that I became fully impressed with the validity of the doubts thrown upon the previously prevailing opinions with respect to such remains in caves" (Phil. Trans., 1860, p. 280); and according to Sir C. Lyell, writing in 1863:—"A sudden change of opinion was brought about in England respecting the probable coëxistence, at a former period, of man and many extinct mammalia, in consequence of the results obtained from the careful exploration of a cave at Brixham. . . . The new views very generally adopted by English geologists had no small influence on the subsequent progress of opinion in France" ("Antiquity of Man," pp. 96, 97).

Bench Cavern.—Early in 1861 information was brought me that an ossiferous cave had just been discovered at Brixham, and, on visiting the spot, I found that, of the limestone quarries worked from time to time in the northern slope of Furzeham Hill, one known as Bench Quarry, about half a mile due north of Windmill Hill Cavern, and almost overhanging Torbay, had been abandoned in 1839, and that work had been recently resumed in it. It appeared that in 1839 the workmen had laid bare the greater part of a vertical dike, composed of red clayey loam, and angular pieces of limestone, forming a coherent wall-like mass, twenty-seven feet high, twelve feet long, two feet in greatest thickness, and at its base 123 feet above sea-level. In the face of it lay several fine relics of the ordinary cave mammals, including an entire left lower jaw of *Hyæna spelæa* replete with teeth, but which had nevertheless failed to arrest the attention of the incurious workmen who exposed it, or of any one else.

Soon after the resumption of the work in 1861, the remnant of the outer wall of the fissure was removed, and caused the fall of an incoherent part of the dike, which it had previously supported. Amongst the *débris* the workmen collected some hundreds of specimens of skulls, jaws, teeth, vertebræ, portions of antlers, and bones, but no indications of man. Mr. Wolston, the proprietor, sent some of the choicest specimens to the British Museum, and submitted the remainder to Mr. Ayshford Sanford, F.G.S., from whom I learn that the principal portion of them are relics of the cave hyæna, from the unborn whelp to very aged animals. With them, however, were remains of bear, reindeer, ox, hare, *Arvicola ratticeps*, *A. agrestis*, wolf, fox, and part of a single maxillary with teeth not distinguishable from those of *Canis isatis*. To this list I may add rhinoceros, of which Mr. Wolston showed me at least one bone.

From the foregoing undesirably, but unavoidably, brief

descriptions, it will be seen that the Devonshire caverns, to which attention has been now directed, belong to two classes,—those of Oreston, the Ash-Hole, and Bench being *Fissure Caves;* whilst those of Yealm Bridge, Windmill Hill at Brixham, Kent's Hole, and Ansty's Cove are *Tunnel Caves.*

Windmill Hill and Kent's Hole Caverns have alone been satisfactorily explored; and besides them none have yielded evidence of the contemporaneity of man with the extinct cave mammals.

Oreston is distinguished as the only known British cavern which has yielded remains of *Rhinoceros leptorhinus* (Quart. Journ. Geol. Soc., xxxvi, p. 456).

Yealm Bridge Cavern, if we may accept Mr. Bellamy's identification in 1835, was the first in this country in which relics of glutton were found (South Devon Monthly Museum, vi, pp. 218–223; see also "Nat. Hist. S. Devon," 1839, p. 89). The same species was found in the caves of Somerset and Glamorgan in 1865 (Pleist. Mam., Pal. Soc., pp. xxi, xxii), in Kent's Hole in 1869 (Rep. Brit. Assoc., 1869, p. 207), and near Plas Heaton, in North Wales, in 1870 (Quart. Jour. Geol. Soc.), xxvii, p. 407).

Kent's Hole is the only known British cave which has afforded remains of beaver (Rep. Brit. Assoc., 1869, p. 208), and up to the present year the only one in which the remains of *Machœrodus latidens* had been met with. Indeed Mr. MacEnery's statement, that he found in 1826 five canines and one incisor of this species in the famous Torquay Cavern was held by many paleontologists to be so very remarkable as, at least, to approach the incredible, until the Committee now engaged in the exploration exhumed, in 1872, an incisor of the same species, and thereby confirmed the announcement made by their distinguished predecessor nearly half a century before (Rep. Brit. Assoc., 1872, p. 46). In April last (1877) the Rev. J. M. Mello was able to inform the Geological Society of London that Derbyshire had shared with Devon the honor of having been a home of *Machœrodus latidens*, he having found its canine tooth in Robin Hood Cave in that county, and that there, as in Kent's Hole, it was commingled with remains of the cave hyæna and his contemporaries (Abs. Proc. Geol. Soc., No. 334, pp. 3, 4).

The Ash-Hole, as we have already seen, afforded the first good evidence of a British reindeer.

In looking at the published reports on the two famous Torbay caverns it will be found that they have certain points of resemblance as well as some of dissimilarity:

1st. The lowest known bed in each is composed of materials which, while they differ in the two cases, agree in being such as

may have been furnished by the districts adjacent to the cavern-hills respectively, but not by the hills themselves, and must have been deposited prior to the existing local geographical conditions. In each, this bed contained flint implements and relics of bear, but in neither of them those of hyæna. In short, the *fourth bed* of Windmill Hill Cavern, Brixham, and the *breccia* of Kent's Hole, Torquay, are coëval, and belong to what I have called the *Ursine* period of the latter.

2d. The beds just mentioned were in each cavern sealed with a sheet of stalagmite, which was partially broken up, and considerable portions of the subjacent beds were dislodged before the introduction of the beds next deposited.

3d. The great bone bed, both at Brixham and Torquay, consisted of red clayey loam, with a large percentage of angular fragments of limestone; and contained *flake* implements of flint and chert, inosculating with remains of mammoth, the tichorhine rhinoceros, and hyæna. In fine, the *cave-earth* of Kent's Hole and the *third bed* of Brixham Cavern correspond in their materials, in their osseous contents, and in their flint tools. They both belong to what I have named the *Hyænine* period of the Torquay Cave.

But, as already stated, there are points in which the two caverns differ:

1st. While Kent's Hole was the home of man, as well as of the contemporary hyæna during the absences of the human occupant, there is no reason to suppose that either man or any of the lower animals ever did more than make occasional visits to Brixham cave. The latter contained no flint chips, no bone tools, no utilized *Pecten*-shells, no bits of charcoal, and no coprolites of hyæna, all of which occurred in the cave-earth of Kent's Hole.

2d. In the Torquay Cave, relics of hyæna were much more abundant in the cave-earth than those of any other species. Taking the teeth alone, of which vast numbers were found, those of the hyæna amounted to about 30 per cent of the entire series, notwithstanding the fact that, compared with most of the cave-mammals, his jaws, when furnished completely, possess but few teeth. At Brixham, on the other hand, his relics of all kinds amounted to no more than 8·5 per cent of all the osseous remains, while those of the bear rose to 53 per cent.

3d. The entrances of Brixham Cavern were completely filled up and its history suspended not later than the end of the Paleolithic era. Nothing occurred within it from the days when Devonshire was occupied by the cave and grizzly bears, reindeer, rhinoceros, cave lion, mammoth, and man, whose best tools were unpolished flints, until the quarrymen broke into it early in A. D. 1858. Kent's Cavern, on the contrary, seems

to have never been closed, never unvisited by man, from the earliest Paleolithic times to our own, with the possible exception of the Neolithic era, of which it cannot be said to have yielded any certain evidence.

Though my "History of Cavern Exploration in Devonshire" is now completed, so far as the time at my disposal will allow, and so far as the materials are at present ripe for the historian, I venture to ask your further indulgence for a few brief moments while passing from the region of fact to that of inference.

That the Kent's Hole men of the Hyænine period—to say nothing at present of their predecessors of the Breccia—belonged to the Pleistocene times of the biologist, is seen in the fact that they were contemporary with mammals peculiar to and characteristic of those times. This contemporaneity proves them to have belonged to the *Paleolithic* era of Britain and Western Europe generally, as defined by the archeologist; and this is fully confirmed by their unpolished tools of flint and chert. That they were prior to the deposition of even the oldest part of the peat bogs of Denmark, with their successive layers of beech, pedunculated oak, sessile oak, and Scotch fir, we learn from the facts that even the lowest zone of the bogs has yielded no bones of mammals but those of recent species, and no tools but those of *Neolithic* type; whilst even the granular stalagmite, the uppermost of the Hyænine beds in Kent's Hole, has afforded relics of mammoth, *Rhinoceros tichorhinus*, cave bear, and cave hyæna.

That the men of the Cave Breccia, or Ursine period, to whom we now turn, were of still higher antiquity, is obvious from the geological position of their industrial remains. That the two races of Troglodytes were separated by a wide interval of time we learn from the sheet of crystalline stalagmite, sometimes twelve feet thick, laid down after the deposition of the breccia had ceased, and before the introduction of the cave-earth had begun, as well as from the entire change in the materials composing the two deposits. But, perhaps, the fact which most emphatically indicates the chronological value of this interval is the difference in the faunas. In the cave-earth, as already stated, the remains of the hyæna greatly exceed in number those of any other mammal; and it may be added that he is also disclosed by almost every relic of his contemporaries—their jaws have, through his agency, lost their condyles and lower borders; their bones are fractured after a fashion known by experiment to be his; and the splinters into which they are broken are deeply scored with his teeth-marks. His presence is also attested by the abundance of his droppings in every branch of the cavern. In short, Kent's Hole was one of his *homes;* he dragged thither, piecemeal, such animals as he found

dead near it; and the well-known habits of his representatives of our day have led us to expect all this from him. When, however, we turn to the breccia, a very different spectacle awaits us. We meet with no trace whatever of his presence, not a single relic of his skeleton, not a bone on which he has operated, not a coprolite to mark as much as a visit. Can it be doubted that had he then occupied our country he would have taken up his abode in our cavern? Need we hesitate to regard this entire absence of all traces of so decided a cave-dweller as a proof that he had not yet made his advent in Britain? Are we not compelled to believe that man formed part of the Devonshire fauna long before the hyæna did? Is there any method of escaping the conclusion that between the era of the Breccia and that of the Cave-earth it was possible for the hyæna to reach Britain?—in other words, that the last continental state of our country occurred during that interval? I confess that, in the present state of the evidence, I see no escape; and that the conclusion thus forced on me compels me to believe also that the earliest men of Kent's Hole were *interglacial*, if not *preglacial*.

The following table will serve to show at one view the co-ordinations and theoretical conclusions to which the facts of Kent's Cavern have led me, as stated briefly in the foregoing remarks. The table, it will be seen, consists of two divisions, separated with double vertical lines. The first, or left hand, division contains three columns, and relates exclusively to Kent's Cavern, as is indicated by the words heading it. The second, or right hand, division is of a more general character, and shows the recognized classification of well-known facts throughout western Europe. The horizontal lines are intended to convey the idea of more or less well-defined chronological horizons, and their occasional continuity through two or more columns denotes contemporaneity. Thus, to take an example from the two columns headed "Archæological" and "Danish-Bog," in the second division: the horizontal line passing continuously through both, under the words "Iron" and "Beech," is intended to suggest that the "Iron Age" of Western Europe and the "Beech" zone of the Danish Bogs take us back about equally far into antiquity; whilst the position of the line under the word "Bronze" indicates that the "Bronze age" (still of Western Europe) take us back from the ancient margin of the Beech era, through the whole of that of the Pedunculated Oak, and about half-way through the era of the Sessile Oak; and so on in all other cases.

KENT'S CAVERN.			PERIODS.				
Deposits.	Bones.	Implements.	Archeolog'al.	Danish-Bog.	Biological.	Geograph.	Climat
Black Mould.	Ovine.	Iron.	Iron.	Beech.	Recent.	Insular.	Post-Glacial
		Bronze.	Bronze.	Pedunculated Oak.			
		and (?)		Sessile Oak.			
		Neolithic.	Neolithic.	Scotch Fir.			
Granular Stalagmite.	Hyænine.	Paleolithic Flakes.	Paleolithic.		Pleistocene.	Continental.	Glacial and (?)
Black Band.							
Cave-earth.							
Crystalline Stalagmite.	Ursine.	Paleolithic Nodules.				Insular.	Inter-Glacial
Breccia.						Continental.	Pre-Glacial

ART. XLV.—*Is the Existence of Growth-rings in the Early Exogenous Plants proof of Alternating Seasons?* An extract from a paper read before the N. Y. Academy of Sciences, March 19, 1877; by CHARLES B. WARRING, PH.D.

WE are told that there must have been the same alternation of seasons before the Glacial Epoch as now, because the exogenous plants of those early times exhibit concentric growth-rings; and consequently the earth's axis must then have been inclined as at present.

But are seasons necessary to the formation of the rings? Until that is established their existence has no importance in this connection. Were it possible in some way to secure a temperature uniform through the year we might be able to determine the question experimentally. The nearest approach to such a condition in this latitude is to be found in green-houses.

The results thus far show that exogenous plants, e. g., the orange and lemon, so placed, form growth-rings as regularly as do the forest trees.

It would be interesting to know how generally exogenous plants in tropical regions exhibit these markings, and whether they are annual or whether they are made at longer or at shorter intervals. I have found it difficult to obtain any information on this point, either from books or from botanists. The latter tell me (I have applied to several botanists of distinction) that they know very little about it. Dr. Gray says, "I know of no exogenous tree that grows continuously. * * * Yet there are exogenous woody stems which do not make annual layers. There is a woody *Phytolacca* which makes more layers, at least twice as many, as it is years old—probably indicating two periods of growth and rest." To this I add that there now lies before me a section of *Chenopodium album* cut on the first of August, and consequently not more than four months old, in which are eight well defined rings. This section is as hard and compact and as well formed wood as if it were a section of ash or pine.

On the other hand there are exogens growing even in this climate, which, notwithstanding our cold winters and hot summers, show not the slightest trace of a ring. I have before me a section of *Akebia quinquefolia* cut by Dr. O. R. Willis on his own lawn from a plant five years old, which has no such markings. Then from a little further south I have a section of the Passion Vine in the same condition; also one of the Iron Wood (*Carpinus Americana*) which presents the faintest possible traces of them. For these also I am indebted to Dr. Willis.

Miss C. C. Haskell, of Vassar College, states the result of her examination of the tropical woods in their museum, as follows: In the *Moria atiara* of the Amazon, the circles are very apparent. In the *Aliso* or *Birch of the Indus*, the circles are evident. They are seen, too, in the *Brazilian Red-wood* (Upper Amazon), and in *Siphonia elastica* or Rubber tree, as well as in the *Moria peranya* of the Rio Negro. None are seen in the *Tortoise Shell Wood* or in the *Cow Tree*."

These suffice to show that, in the uniformly warm climate of the tropics, rings are formed as regularly as in the trees of our northern forests. But it may be said that although there is in these regions no alternation of hot and cold seasons, yet that they do undergo semi-annual changes from wet to dry, and from dry to wet, and that, these being dependent upon the earth's axial inclination, we are not at liberty to infer that the rings would have been formed had there been the absolutely seasonless condition which a perpendicular axis would produce. But there is evidence that exogenous trees would form these

marks in a climate of absolutely no variation. I have before me a section of *Mangrove* also presented by Dr. Willis. This tree, as is well known, grows in the muddy margins of tropical rivers and all along the shores, forming dense forests even at the verge of the ocean and below high-water mark. In such a locality there can be no alternation of wet and dry seasons, and the changes of annual temperature must be less than the diurnal. It would seem impossible to conceive of greater uniformity of temperature and moisture, yet this tree presents the growth rings as broad and as well defined as those which are seen in any trees anywhere.

To dispel any vestige of belief that seasons and these markings are connected as cause and effect, I add that the *Cycads* require several years to form one ring.

The consideration of these facts leads to the conclusion that these circles have their origin in cycles of activity and repose, implanted in the constitution of the plant, which would continue to manifest themselves although there were no climatic variations—a conclusion strengthened by the experience of all who have attempted, by artificially equalizing the temperature, to make their plants bloom all the year. It is true that where seasonal variations exist, the successive stages of activity and rest are for obvious reasons synchronous with them, but they are not absolutely dependent upon them.

We may conclude, too, that the pre-glacial flora exhibited similar cycles of growth and rest, some of which may have been of short duration, measured perhaps by weeks, like those of the *Chenopodium*, while others like the *Cycads* may have required several years for their completion.

The following propositions appear to be established by the facts which have been presented.

1. Some exogens form rings at intervals much less than a year.
2. Others require intervals of several years.
3. Some form no rings.
4. The presence or absence of rings in exogens occurs in all climates.
5. Large and well defined rings are found under conditions in which there is absolutely no appreciable variation of temperature or moisture throughout the year.
6. An exogen naturally forming rings, will continue to form them although the climate become uniform through the year.

The existence, therefore, of these markings in the ancient flora gives no information as to the existence at that time of seasons, and so far as they are concerned we are left free to adopt any conclusion as to the inclination of the earth's axis which may appear to us most reasonable.

ART. XLVI.—*On Sipylite, a new Niobate, from Amherst County, Virginia;* by J. W. MALLET.

THE allanite found in Amherst County in this State, of which an analysis by Mr. J. A. Cabell, was published in the Chemical News, 1874, p. 141, occurs in large quantity, and furnishes an abundant source of supply of the cerium family of metals. In picking over a lot of three or four hundred pounds of it, I was struck with the appearance of a few fragments of an accompanying mineral, which on more careful examination turns out to be a new niobate.

The locality in question is on the northwest slope of Little Friar Mountain, about fifteen miles from the Virginia Midland Railway. The allanite is said to occur in a vein of more or less decomposed feldspar in a gneissoid rock, and is met with in large, but very imperfect crystals, and loose lumps of irregular shape, about four feet below the surface of the ground. Magnetite is found with it, the two minerals often forming parts of the same mass; and in going down the vein seems to become more compact, and tends to pass into solid magnetic iron ore. The vein is said to be about two feet wide, and runs about northeast and southwest, dipping at a large angle to the southeast.

Beside allanite, magnetite, and the new mineral now to be described, I have only noticed among the specimens which have reached me a few large crystals of hydrous zircon. One of these measured about $30 \times 18 \times 13$ mm., was doubly terminated, of sp. gr. $= 4{\cdot}217$, and yielded on ignition 1·89 per cent of water.

The new mineral is decidedly rare; all the specimens I have collected were picked out from three lots of the allanite, two of them of several hundred pounds each, and would probably not weigh half a kilogram; the largest single piece weighs about forty grams; most of the fragments are much smaller. It is found imbedded in, or more commonly adherent to, the outside of the masses of allanite and magnetite, from which it is easily detached.

A few imperfect crystalline faces have been met with, but none of these brilliant, and only two dihedral angles that could be, even in a very rough way, measured with the application of a goniometer; each of these was about 125°, which is not far from $I \wedge I$ of the prism of yttro-tantalite, samarskite, and euxenite. There were observed also a few very imperfect cleavage planes. For the most part the mineral appears in little, irregularly shaped masses, very brittle, and exhibiting small, but distinct, conchoidal, as well as uneven fracture.

The color of the mineral in mass is brownish black, in thin splinters a red brown, like that of dark pine-rosin; one or two small specimens display a gradual passage to a brownish orange, and even a yellow, but whether in these cases the chemical composition remains quite the same, there is not sufficient material to determine. The streak is light cinnamon-brown to pale gray. The luster resinous and pseudo-metallic. In general appearance to the eye the mineral is much like fergusonite from Greenland, euxenite from the neighborhood of Arendal, and samarskite from North Carolina, save that the last named is more distinctly pitchy black. Translucent in thin splinters. Hardness = nearly 6. Specific gravity may be considered = 4·89; one specimen gave 4·887 at 12°·5 C.; another 4·892 at 17°·5.

Heated alone in the ordinary blowpipe flame the mineral cracks, decrepitates, *glows brilliantly* (more brightly, I think, and at a lower temperature than any specimen of gadolinite I have ever seen), becomes pale greenish-yellow and opaque, like many specimens of good blast-furnace slag, and remains quite infusible. In the flame of one of Fletcher's hot-blast blowpipes, before which a stout blowpipe wire of platinum readily melts to a bead, thin splinters are fused merely on the edges. Heated in a closed glass tube, the same decrepitation, glowing and change of color are observed, and water is given off, which condensing on the surface of the tube is found to have an acid reaction, and slightly etches the glass. Fused with borax in the oxidizing flame, the mineral is dissolved, producing a yellow glass, which becomes pale on cooling, and assumes a greener tint in the reducing flame. With microcosmic salt, a yellowish green glass is obtained. Strong boiling hydrochloric acid attacks to some extent the mineral in fine powder, and the partial solution, if boiled with metallic tin and diluted with water, gives the fine sapphire-blue color due to niobium. This partial hydrochloric acid solution, if diluted, contains zirconium enough to brown turmeric paper to an extent quite sensible if a comparative experiment be made with similarly diluted hydrochloric acid alone. Boiling concentrated sulphuric acid decomposes the mineral completely, though somewhat slowly; and the diluted solution gives a blue color on addition of metallic zinc.

The chemical analysis was made, with much care and patience, under my direction by Mr. W. G. Brown, a student in this laboratory during the last winter. The details of the method used are given in a notice of his work in the Chemical News. Tantalum was found to be present, but in such small quantity, certainly less than one-twelfth of the niobium, that a satisfactory separation could not be obtained by Marignac's method. The sp. gr. of the mixed niobic and tantalic oxides

was 4·60. By determination of the yttrium and erbium first as oxides and then as sulphates it was found that the mixture contained almost exclusively the latter metal, of which the absorption spectrum is obtainable with great distinctness from the crude solution. Iron and uranium were proved to exist as ferrous and uranous compounds. The following results were obtained:

Nb_2O_5	48·66
Ta_2O_5*	
WO_3	·16
SnO_2	·08
ZrO_2	2·09
Eb_2O_3	27·94
Y_2O_3†	
Ce_2O_3‡	1·37
La_2O_3§	3·92
Di_2O_3‖	4·06
UO_2	3·47
MnO	trace
FeO	2·04
BeO	·62
MgO	·05
CaO	2·61
Li_2O¶	trace
Na_2O	·16
K_2O	·06
F	trace
H_2O	3·19
	100·48

Throwing together, as Rammelsberg has done in his valuable paper** on the natural tantalates and niobates, the acid oxides of niobium, tantalum, tungsten, tin and zirconium, reducing all the basic oxides present to the equivalent amounts of dyad oxides, and leaving out the water, we have from the above figures the ratio,

$$R''O : M^v_2O_5 = 221 : 100$$

leading to the formula $R''_3M^v_2O_8 \cdot 4\,R''_2M^vO_7$, or, applying the common phosphate nomenclature, a single atomic group of ortho-niobates with four of pyro-niobates; while samarskite, according to the calculation of Professor O. D. Allen†† from his analysis, contains one to one, or is represented by the formula

* Ta_2O_5 may be assumed = about 2 per cent.

† Y_2O_3 may be assumed = about 1 per cent.

‡ Cerous oxide, but with Cléve's formulæ and atomic weights for this and the corresponding oxides of lanthanum and didymium.

§ Containing a trace of Di_2O_3.

‖ Containing a trace of Ce_2O_3.

¶ Spectroscopically detected.

** Jour. Chem. Soc., March, 1872, p. 189.

†† This Journal, August, 1877, p. 131.

$R''_3M^v_2O_8 . R''_2M^v_2O_7$, and Rammelsberg makes pyrochlore from Fredriksvärn solely the pyro-niobate, $R''_2M^v_2O_7$, and fergusonite, tyrite, etc., solely the ortho-salt, $R''_3M^v_2O_8$.

If, however, the water be included in the calculation, and considered basic, placing it on an equivalent footing with the dyad oxides we have the ratio,

$$R''O : M^v_2O_5 = 311 : 100, \text{ or nearly } 3 : 1,$$

which gives the simple formula of an ortho-salt, $R''_3M^v_2O_8$. This I confess I am inclined to think more probable, and, if so, it may be allowable to suppose that the very remarkable glow exhibited by the mineral when heated is connected with the loss of basic water and the change from ortho- to pyro-niobate, as in the well known incandescence of ammonio-magnesian ortho-phosphate at the moment of change by heat to the pyro-phosphate of the latter metal.*

Whichever formula be preferred, however, for the mineral now described, it differs essentially from that of any niobate hitherto on record, the one view making it the nearest approach to a simple pyro-*niobate* (since the Fredriksvärn pyrochlore contains largely of titanium) and the other making it an ortho-salt like fergusonite, etc., but one partially acid in character or containing basic hydrogen.

Not on chemical grounds alone, but in several respects as to physical properties, the mineral is new and distinct. Carrying out the fancy of Heinrich Rose, which led him to name niobium from the daughter of Tantalus, and remembering the number and complexity of the natural niobates which have been met with, I propose for this species the name Sipylite, from Sipylus, one of the numerous children of Niobe.

***It may be worth remarking that from the analysis of Professor Allen (loc. cit.) of Professor J. Lawrence Smith's new mineral, hatchettolite, which accompanies samarskite in North Carolina, water seems to be present in it in definite proportion; and, although Rammelsberg has considered the water found in his analyses of tantalates and niobates as non-essential, and the formula, $R''_3M^v_2O_8$, which he has assigned in common to fergusonite, yttro-tantalite, tyrite and bragite, requires that water be excluded, if it be also taken into account his analyses of these minerals lead pretty closely to simple relations as to the extent of hydration (without considering the water basic), making**

Fergusonite, from Greenland (with very little water)—$R''_3M^v_2O_8$, or perhaps $2R''_3M^v_2O_8 . H_2O$.

Brown yttro-tantalite, from Ytterby
Yellow " " " "
Tyrite
Bragite
} **$2\ R''_3M^v_2O_8 . 3H_2O$.**

Gray yttro-tantalite, from Gamle Kararfvet — $2R''_3M^v_2O_8 . 5H_2O$.

University of Virginia, Sept. 3, 1877.

ART. XLVII.—*On the Mean Motion of the Moon;* by SIMON NEWCOMB.

FOR some time after the appearance of Hansen's Lunar Tables, it was very generally considered that the theory of the moon, after occupying the attention of the mathematicians and astronomers of every century for two thousand years, was at length complete, and that the motion of that body could now be predicted with entire confidence. That Hansen's computation of the inequalities of short period produced by the sun not only far exceeded in accuracy any before made, but fulfilled all the requirements of modern astronomy, I conceive can hardly be doubted. But in the number of this Journal for September, 1870, I showed that this improvement did not extend to the inequalities of long period in the mean motion. While it was true that Hansen by an empirical term had secured a very good agreement with observations from 1750 to 1860, it was there shown that this agreement had been obtained by sacrificing the agreement before 1750, and that the moon had then begun to deviate from the tables at such a rate that they could not continue satisfactorily to represent the observations. During the seven years which have since elapsed, this suspicion has been entirely confirmed. So far as can be judged by the most recent observations, the error of the tables now exceeds ten seconds, and is increasing at a rate of not less than half a second a year.

Shortly after the publication of the short paper to which I have alluded, it was made a part of my official duty to investigate this question. In accordance with this arrangement, I have aimed at the complete discussion of all recorded observations of any astronomical value before the year 1750. These researches now being brought substantially to a close, so far as the observations are concerned, the object of the present article is to give some account of them, and of their results. The material consists in brief, of every observation of an eclipse or an occultation previous to 1750, which appears to be worthy of confidence, and calculated to throw any light upon the question of changes in the moon's mean motion. The available data may be classified as follows:—

I. Accounts of ancient historians from which it has been inferred that the shadow of the moon passed over certain points of the earth's surface during certain total eclipses of the sun. The celebrated eclipses of Thales, of Larissa, and of Agathocles have been very carefully discussed by Professor Airy in two papers which have appeared, the one in the Philosophical Transactions, and the other in the Memoirs of the Royal Astronomical

Society. After a careful examination of the six or eight eclipses in question, I was led to the conclusion that none of them could be safely relied upon as furnishing data for the error of the Lunar Tables at the times when they were observed. It is impossible, within the limited space of the present article, to enter into any details of the considerations which led me to this conclusion. It may be remarked, however, that among the eclipses in which I can feel but little confidence is the celebrated one of Thales. To prevent misapprehension I may say that I do not deny either that Thales predicted eclipses or that the shadow of the moon passed over Asia Minor, B.C., 585 as indicated by the Lunar Tables, or that a battle was stopped by some real or fancied advent of darkness, as described by Herodotus a century afterward; but I fail to see any good reason for maintaining that the extremely obscure account of Herodotus really refers to the total eclipse in question, or, in fact, to any eclipse whatever. Consequently, while these eclipses may be useful in throwing more or less of evidence on the question of the moon's secular acceleration, I do not think they can be considered reliable enough to be used for determining that quantity.

II. The second class comprises the nineteen eclipses of the moon quoted by Ptolemy in the Almagest, on which he founded his theory of the moon's motion. These eclipses appear to be worthy of some confidence, making due allowance for the very considerable errors of observation with which they are necessarily affected. The mode of treatment was this: from a very careful study of the account of each eclipse as given by Ptolemy, and without any knowledge of how it compared with the tables, I sought to make an estimate, first, of the most probable time of the phase described, and second, of the probable error of that time. These estimates I shall publish without any alteration suggested by the subsequent comparison with the tables. When this comparison was made, it was found that the general deviations of the tabular from the recorded times did not indicate a probable error essentially greater than that estimated, except in two cases.

There are five eclipses in which Ptolemy does not say to what phase the time which he gives refers. It has very generally been considered that in these cases the phase was that of the middle of the eclipse; but in all other cases the time which he gives is that of commencement; and there would be a certain probability in favor of the times where no phase was given being also those of commencement. The errors in question were systematically different from those of the other eclipses, and seemed to indicate that in these eclipses also, the beginning was referred to. Owing, however, to the uncertainty of this

entire hypothesis, I judged it best to reject these eclipses entirely, and confine the discussion to the fourteen remaining ones.

Among these fourteen, which, in some cases, include the end of the eclipse as well as the beginning, there was a single one, that of B.C., 382, December 22, which was in contradiction with all the others. The other thirteen all agree in the most remarkable manner in assigning a correction of more than half an hour to the tabular times; while this one indicated a negative correction. This discordance, however, is not the most perplexing circumstance. It happened that this eclipse commenced just before sunrise, and therefore just before the moon set; and if the other eclipses were accurate, this one could not have been seen at all. If this one really was seen, it would almost necessitate a negative correction to the tabular times. We have then this dilemma: either the whole thirteen eclipses recorded by Ptolemy are, with a single exception, half an hour or more in error, or there is some mistake about this eclipse having been actually observed. Deeming the latter the more probable of the two hypotheses, I threw out this eclipse entirely. Of the twelve remaining eclipses, sixteen phases were observed, which were divided into four groups, and the mean result, by weight, of each group was taken. The mean corrections to the tabular times given by the several groups, are as follows:—

Epoch, − 687	$\delta t = +20^m$	$\delta\varepsilon = -11' \pm 4'$	3 phases.
− 381	$\delta t = +50$	$\delta\varepsilon = -27 \pm 5$	3 phases.
− 189	$\delta t = +36$	$\delta\varepsilon = -20 \pm 3$	8 phases.
+ 134	$\delta t = +30$	$\delta\varepsilon = -16 \pm 4$	3 phases.

III. The next observations in order are the eclipses observed by the Arabian astronomers between the years 829 and 1004, which are published in the work entitled Le Livre de la Grande Table Hakémite, traduit par le C^en^. Caussin, Paris, 1804. This work is a translation of the Arabic manuscript belonging to the University of Leyden. A few of the observations were known to Tycho Brahe and were published by him in his Historia Cœlestis. As a slight indication of the value of these eclipses it may be remarked that the two or three given by Tycho Brahe furnished the first data from which the secular acceleration of the moon was deduced. It is therefore a singular fact that no comparison of them with modern tables has ever been seriously attempted.

There are, in all, in this book, observations of twenty-five eclipses including thirty-four phases of beginning or ending. They were all reduced and compared with the tables of Hansen. Three of them were so far discordant that they had to be rejected entirely. This ratio of three out of thirty-four will not appear great if we reflect that the manuscript from which the

observations were translated, was frequently very difficult to decipher or to translate, owing not only to the fading of the writing, but to the uncertainty of some of the terms which the author used. Besides these three discordant observations, there were two which could not be used because the altitude assigned to the moon at the time of the observation actually exceeded its meridian altitude. Here it was evident that there was something wrong, in recording, transcribing or translating the observation. The general result was that each observation of a phase gave the mean longitude of the moon with a probable error ranging from three to five minutes of arc. The results were divided into three groups, each made by a separate observer or set of observers, and therefore worthy of being considered as entirely independent. The mean result of each of these groups was as follows:—

Epoch, 846	$\delta\varepsilon = -4'\cdot4$
926	$\delta\varepsilon = -1\cdot1$
986	$\delta\varepsilon = -4\cdot8$

IV. Observations made after the revival of science in Europe and before the invention of the telescope. These observations were made by various astronomers from Regiomontanus to Tycho Brahe. But after a careful and laborious examination of all their observations I could find, I was led to the conclusion that none of them would throw any light on the problem. Before Tycho Brahe the observations were no better than those of the Arabs, while the time elapsed was one half that which has elapsed since the Arabian observations. No doubt the observations of Tycho Brahe are more accurate; but the records are so confused that it is impossible to obtain any definite result from them. In fact they preceded the invention of the telescope by so short an interval that it can hardly be supposed that they would throw much light on the question under consideration, however carefully they had been made. I searched carefully to find whether Tycho Brahe had ever observed an occultation, especially of Aldebaran; but could find no trace of any such observation.

V. Observations of occultations and eclipses made with a telescope but without a clock, the time being determined by the altitude of the sun or of some star observed with a quadrant. This class comprises the observations of Bullialdus and Gassendus, as well as some of the earlier of Hevelius. Bullialdus seems to have been the first one who actually observed the occultation of a star by the moon, but he does not appear to have been a skillful observer. The observations of occultations have the great advantage that the only error to be feared is that of the determination of time, always supposing that the phenom-

enon was actually seen. The disappearance of the star behind the moon's limb is, in fact, a sudden phenomenon which does not require any measure of distance to be well observed.

VI. Observations of eclipses and occultations made by Hevelius with a very imperfect clock regulated by altitudes taken with a quadrant with pinnules. It is well known that Hevelius would never use a telescope with his quadrant; so that the results to be derived from the observations of this most indefatigable observer do not correspond to the labor which he spent in making them. His observations are much better than those of Gassendus, but far more inaccurate than those made with the telescopic sights.

VII. Observations of Flamsteed at Greenwich, and of the astronomers of the French school, from 1672 to 1750. Flamsteed's observations were published in the Historia Cœlestis. Those of the French astronomers are not only for the most part unpublished, but seem to have been totally forgotten from the time they were made until I was fortunate enough to find them in the archives of the Paris Observatory in 1871. Not only were they wholly unreduced, but in many cases not even the name of the occulted star was given. The reduction of these observations has been the most laborious part of my work. The observers have left no explanations whatever of their mass of observations, and it was necessary to learn this by induction from the observations themselves; and from the calculations scattered here and there through the books. The errors of the instruments and of the clocks had to be investigated from modern data; and the observations have proved to be well worthy of the pains which were taken with them. Thereby, the motion of the moon has been traced back to 1675, an epoch seventy-five years before observations upon it have heretofore been supposed to commence. In the same class with these Paris observations are to be included those of DeL'isle at St. Petersburgh, with which I was furnished by Struve.

The following are some independent mean corrections given by the observations of Bullialdus, Gassendus, Hevelius, Flamsteed, and the French astronomers. The list is incomplete, as the discussion of the solar eclipses has not been finished; but it will suffice for the purposes of the present discussion:—

1621	+ 77″	1661	+ 37″
1630	+ 30	1666	+ 24
1633	+ 53	1680	+ 30·4
1635	+ 55	1682	+ 2[illegible]·5
1639	+ 23	1715	+ 13·8
1645	+ 51	1725	+ 7·0
1652	+ 38		

The investigation is terminated at the epoch of 1750 so far as the reduction of observations is concerned, because there is reason to believe that Hansen's tables are not greatly in error from 1750 to 1865. We may, therefore, in this preliminary discussion consider the tabular errors zero between these epochs. For the epoch 1875 the correction given by some good observations of occultations is $-8''.0$, a result $1''.7$ less than that indicated by the observations at Greenwich and Washington. This discrepancy is quite surprising. It is, however, worthy of remark that Captain Tupman from a discussion of all the meridian observations made in Europe about the time in question obtained a mean result somewhat less than that given by Greenwich and Washington alone. It is well known that Hansen's term depending on eight times the mean motion of Venus minus thirteen times that of the earth is almost entirely empirical, being adjusted so as to satisfy the observations between 1750 and 1850. And since this term fails to satisfy the observations outside of these limits, in fact making the tables worse than they would be without it, it ought to be rejected from the comparison of theory with observation. Its effect upon the ancient results is, however, so small in comparison with the necessary error of the observations that its effect need not be taken into account.

From the individual corrections to the moon's mean longitude which have been given for the modern dates I have sought to obtain by a rough interpolation the actual corrections for every quarter of a century from 1625 to 1725. The general results are shown in the following table, of which I shall explain the several parts:

Table of residual corrections to the several theories of the mean motion of the moon.

Epoch.	(1) Hansen.	(2) H′.	(3) $s=8''.8$.	(4) $s=6''.18$.	(5) Δt.
−687	−11′	−11′	+16′	+39′	−70^m
−381	−27	−27	− 7	+10	−18
−189	−20	−20	− 4	+10	−17
+134	−16	−16	− 6	+ 4	− 6
846	− 4·4	− 4·4	− 2·4	− 0·2	0
926	− 1·1	− 1·1	+ 0·3	+ 2·1	− 4
986	− 4·8	− 4·8	− 3·8	− 1·3	+ 2
1625	+50″	+33″	+ 6″.1	− 6″·6	+12^s
1650	+39	+18	− 6·9	−19·0	+ 3
1675	+32	+15	− 7·4	−18·6	+34
1700	+21	+16	− 3·6	−13·5	+25
1725	+ 7	+16	− 0·3	− 8·6	+16
1750	0	+19	+ 6·4	0·0	0
1775	0	+21	+12·5	+ 8·4	−15
1800	0	+15	+11·1	+ 9·5	−17
1825	0	+ 2	+ 3·0	+ 4·4	− 8
1850	0	−11	− 4·6	0·0	0
1875	− 8	−28	−15·8	− 7·6	+14

In column (1) we have the mean correction indicated by observations to Hansen's tables of the moon without any modification whatever. In column (2) these corrections are modified by the effect of Hansen's empirical term, so as to show the corrections to the pure theory after this term is subtracted from the tables. If the theory is perfect, these numbers ought to be represented by corrections to the mean longitude and mean motion of the moon and the secular acceleration.

The following are the several corrections given by the method of least squares:

$$\left.\begin{aligned} \delta e &= +19''\cdot57 \\ \delta n &= -12\ \cdot31 \\ \delta s &= -\ 3\ \cdot36 \end{aligned}\right\} \text{Epoch, 1700.}$$

The value of the secular acceleration adopted by Hansen is $12''\cdot17$. Subtracting the correction it seems that the acceleration to which we are led by observation alone, is $8''\cdot8$.

Column (3) shows the outstanding corrections which remain after subtracting the result of the corrections we have just found. It is evident that the theory does not represent the observations, and that the most recent observations indicate a value of the secular acceleration much less than that indicated by the older ones. If we investigate the uniform variation of the acceleration which would best satisfy the whole of the observations, we shall find it to be $-0''\cdot9$ in a century. The hypothesis of such a uniform variation is, however, too improbable to be admitted; and moreover, it still fails to represent the modern observations, although the ancient ones are thus greatly improved.

In recent times it has been generally considered that the difference between the theoretical acceleration and that given by observations arises from a change in the length of the day. It is worthy of remark that by supposing this change itself subject to variations, all the apparent changes in the mean motion of the moon can be accounted for. This is a hypothesis which I have suggested in former numbers of this Journal, as one by which the changes in question may be explained. Let us now see what the actual variations in the rotation of the earth must be to account for the difference between observation and theory. In the first place, the secular acceleration must be supposed to be uniform and equal to $6''\cdot17$. Two epochs at which we may suppose the time given by the rotation of the earth to be correct, being entirely arbitrary, we shall take 1750 and 1850 for these epochs. Having thus formed a theory of the moon's mean motion founded on gravitation alone, column (4) shows the apparent corrections indicated by observation. In column (5) these corrections are changed into time. The times here given are

hypothetical errors of the earth's rotation which it is necessary to subtract from the times given by astronomical observations in order to reduce them to a perfectly uniform measure of time. The sign + indicates that the earth is ahead of its mean rotation, and the sign − that it is behind it. For some years past it has seemed to me that this was the most probable hypothesis on which to explain the deviations in question. It was evidently a most unwelcome one; for, granting its truth it would be no longer possible to predict the apparent motion of the moon, since the changes in the rotation of the earth could not be expected to follow any determinate law. It is therefore extremely gratifying to find that the comparisons we have just given lead to the hope that these deviations may, after all, be due to the action of some of the bodies of the solar system. A very cursory examination of the residuals given in column 3 shows that they have apparently a period not very far from 260 years. Now, it is remarkable that this differs very little from the period of Hansen's first inequality, which is 273 years. The question therefore arises whether the deviations in question may not be explained by a change in the constants of this inequality. The result is very surprising. By merely diminishing the argument of Hansen's first inequality by 60° 48′ without changing the co-efficients at all, the observations from 1625 to 1875 may all be represented within the limits of error. In fact, we see that the numbers in column (3) may be very nearly represented by the formula

$$-5''.04 - 10''.14\left(\frac{t-1800}{1800}\right) - 15''.50\cos A,$$

in which we have placed,

$$A = 18V - 16E - g,$$

V being the mean longitude of Venus counted from the equinox of 1800, E that of the earth counted in the same way, and g the mean anomaly of the moon. The comparison in question is shown in the following tables; the fourth column of which is taken from the corresponding column of the preceding table. The residuals still outstanding are shown in the last column.

Epoch.	A.	Computed terms.	Observ.	Diff.
1625	−47°·0	+2″·2	+6″·1	+3″·9
1650	−14 ·0	−4 ·7	−6 ·9	−2 ·2
1675	+19 ·0	−7 ·1	−7 ·4	−0 ·3
1700	52 ·0	−4 ·5	−3 ·6	+0 ·9
1725	85 ·0	+1 ·2	−0 ·3	−1 ·5
1750	118 ·0	+7 ·3	+6 ·4	−0 ·9
1775	151 ·0	+11 ·0	+12 ·5	+1 ·5
1800	184 ·0	+10 ·4	+11 ·1	+0 ·7
1825	217 ·0	+4 ·8	+3 ·0	−1 ·8
1850	250 ·0	−4 ·8	−4 ·6	+0 ·2
1875	283 ·0	−16 ·0	−15 ·8	+0 ·2

Correcting Hansen's term by this empirical addition, we find that instead of

$$15''\cdot34 \sin (A+30^\circ\cdot2),$$

the value given by Hansen, we shall have

$$15''\cdot3 \sin (A-30^\circ\cdot6),$$

as the result of observation.

As a test of this result, the sum of all the corrections here found to Hansen's tables has been taken and compared with the corrections given in column 1. It is to be remarked in the first place that the diminution of $10''$ a century in the mean motion of the moon involves a further correction of $-0''\cdot4$ to the value of the secular acceleration in order that the ancient observations may still, on the average, be best represented. Thus the secular acceleration reduces to

$$8''\cdot4;$$

and the total correction to the acceleration of Hansen is

$$-3''\cdot76.$$

We put V_2 for the empirical term of Hansen,

$$21''\cdot47 \sin (8V-13E+274^\circ\ 14'),$$

the existence of which appears to have been entirely refuted by the researches of Delaunay; and T for the time counted in centuries after 1800. Then the total corrections to the tables of Hansen are as follows:—

$$-V_2 - 1''\cdot14 - 29''\cdot17\,T - 3''\cdot76\,T^2 - 15''\cdot5 \cos A.$$

The following are the values of these corrections for the principal epochs from 1625 to 1900. The computation and comparison with observation is given so fully that any explanation of the table appears to be unnecessary.

Epoch.	$-V_2$	$-15''\cdot5$ cos A.	$-1''\cdot14 - 29\cdot17\,T - 3\cdot77\,T^2$.	Sum.	Observation.	Diff.
1625	$+17''\cdot1$	$-10''\cdot6$	$+38''\cdot4$	$+44''\cdot9$	$+50''$	$+5''$
1650	21·4	−15·0	34·1	40·5	39	−1·5
1675	16·9	−14·7	29·4	31·6	32	+0·4
1700	+ 5·2	− 9·5	24·3	20·0	21	+1·0
1725	− 8·6	− 1·4	18·6	8·6	7	−1·6
1750	−18·9	+ 7·3	12·5	+ 0·9	0	−0·9
1775	−21·2	13·6	+ 5·9	− 1·7	0	+1·7
1800	−14·7	15·4	− 1·1	− 0·4	0	+0·4
1825	− 2·1	12·4	− 8·7	+ 1·6	0	−1·6
1850	+11·4	5·3	−16·7	0·0	0	0·0
1860	15·7	+ 1·8	−20·0	− 2·5	+1·5	+4·0
1870	19·0	− 1·7	−23·4	− 6·1	−5·5	+0·6
1880	20·9	− 5·2	−26·9	−11·1	----	----
1890	21·4	− 8·4	−30·4	−17·4	----	----
1900	+20·6	−11·2	−34·1	−24·7	----	----

The only case in which the difference exceeds the possible error of the comparisons is at the epoch 1860. As an explanation of this I can only suggest that the term found by Mr. Neison as due to the action of Jupiter is at that time added to the result of a possible error in Hansen's value of the term which depends upon the ellipticity of the earth. The comparison may therefore be improved when the theory is suitably corrected.

The great question which now arises is this. Is it possible that this correction to the term produced by the action of Venus can really be a result of the attraction of that planet? We are struck by the fact that the proposed change can be expressed by a mere change of the algebraic sign of the constant term of the argument, leaving the value of the co-efficient unchanged. It may therefore be inquired whether it is possible that the sign of this quantity is erroneous in Hansen's formula. This question must be answered in the negative. I have found by an investigation still unpublished, substantially the same result as Hansen; while the researches of Delaunay published in the Connaissance des Temps for the year 1862 show that the approximate expression of the constant term in question, is

$$180°-2h'',$$

h'' being the longitude of the node of Venus, which does not differ much from 75°. It is, therefore, a mere chance that the change of Hansen's term can be expressed in this way.

Although Hansen, Delaunay, and myself have all arrived at the same result for the value of the term in question, I cannot confidently say that that result is complete. In all three computations the terms of the second order due to the mutual attraction of Venus and the earth are neglected. It is evident that in consequence of this mutual attraction, the direct action of Venus on the moon is different from what it would be if each planet moved in its elliptic orbit. It may be that this difference is sensible in terms of so high an order as those under consideration. I have actually computed the additional terms in $\frac{1}{\Delta^3}$ (Δ being the distance of Venus from the earth) which arise in this way and which depend upon the argument 18V−16E. The result is that the values of the several parts which make up this term are quite comparable with those of the elliptic terms which depend on the same argument; but these co-efficients destroy each other in taking the sum. I have, however, always regarded my computations on this subject as incomplete, and have, in consequence, never published them.

As the case stands, the marked agreement between theory and observation which is produced by the introduction of this empirical term, seems to me such as to warrant its provisional use until a more careful investigation of the subject can be made.

Washington, Oct. 3, 1877.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Action of Saline solutions on Lead.*—Muir has examined the action exerted by various saline solutions upon lead, with and without access of air, with a view to explain the mechanism of the process. The lead used was sold as pure, and contained only traces of manganese, zinc and iron. Three parallel series of experiments were tried, one in corked flasks, another in beakers covered with paper, and a third in basins, similarly covered. Twenty-five square centimeters of lead were used in each experiment, being placed in a solution of 2·0 gram per liter, of one of the following salts: ammonium nitrate, potassium nitrate, calcium chloride, ammonium sulphate or potassium carbonate, for a time varying from 14 to 21 days. In the corked flask the maximum effect took place in the calcium chloride solution, 1·9 milligrams of lead being dissolved in 14, and 3 milligrams in 21 days; while in the open beaker, ammonium nitrate dissolved from 2 to 4 milligrams, and in the open basin, the nitrate and sulphate each dissolved from 8 to 16 milligrams. The order of solvent power is NH_4NO_3, $CaCl_2$, $(NH_4)_2SO_4$, KNO_3, K_2CO_3. In general, access of air increases the action. The lead deposit formed was a plumbic hydrocarbonate $(PbCO_3)_2$, $Pb(OH)_2$ or $Pb\begin{cases}OH\\O\\O\\Pb\\O\\O\\Pb\\OH\end{cases}CO\;CO$, in fine silky scales. It was found to be more soluble in ammonium nitrate when air was excluded (one part in 4,600), and in calcium chloride with access of air (one part in 26,000), though its solubility was very great in carbonic acid water (one part in 4,300). The author believes that in the action of saline solutions upon lead, a soluble salt is first produced; that carbon dioxide is slowly absorbed from the air, converting the lead into hydrocarbonate, which is mostly precipitated; that in certain liquids the formation of the soluble salt proceeds at first more rapidly than its precipitation, but that later the latter action preponderates; and that carbonates precipitate the lead salt as fast as it is formed, in the form of hydrocarbonate.—*J. Ch. Soc.*, xxxi, 660, June, 1877. G. F. B.

2. *New Method for the Synthesis of Hydrocarbons.*—Friedel and Crafts, in examining the action of finely divided aluminum upon organic chlorides, which is at first very slow, but becomes more rapid, found that the aluminum chloride formed in the reaction was the active agent in evolving the hydrogen chloride, remaining itself unaltered. If, for example, amyl chloride be treated with the anhydrous chloride, hydrochloric acid gas is

evolved in the cold, as well as a mixture of gases not absorbable by bromine. In the residue, beside the unaltered Al_2Cl_6, are contained various hydrocarbons, some of high boiling point. If, however, the amyl chloride be mixed with a hydrocarbon, such as benzene in excess, the evolution of gas is regular, and the liquid separates into two layers, the upper one of which is a solution of amyl-benzene in excess of benzene, the lower, one of Al_2Cl_6. Iodides and bromides act similarly, though not as uniformly. Ethyl iodide treated as above gave ethylbenzene, methyl chloride gave toluene (methyl-benzene), xylene (dimethylbenzene) mesitylene (trimethylbenzene) and durene (tetramethylbenzene), benzyl chloride gave diphenylmethane, chloroform gave triphenylmethane and carbon tetrachloride gave tetraphenylmethane. Acid chlorides act in the same way. Benzoyl chloride dissolved in benzene, gives, by the action of aluminum chloride, the ketone benzophenone, acetyl chloride gives acetophenone, phthalyl chloride gives phthalophenone and another product, probably anthraquinone. Further examination showed that zinc and ferric chlorides acted similarly in the cold, ferrous chloride on warming. Copper, cobalt, and magnesium chlorides appeared to be without action. The authors explain the reaction by supposing an aluminum organic compound to be first formed and then decomposed, regenerating the chloride, thus:

$$C_6H_6+Al_2Cl_6=HCl+Al_2Cl_5(C_6H_5)$$

$$Al_2Cl_5.(C_6H_5)+(CH_2C_6H_5)Cl=Al_2Cl_6+(CH_2.C_6H_5)C_6H_5.$$

—*J. pr. Ch.*, II, xvi, 233, Aug., 1877. (*C. R.*, lxxxiv, 1392, 1450).

G. F. B.

3. *The Terpenes of Swedish Wood Tar.*—Atterberg has examined a so-called "wood oil," which is the first product of distillation of the wood tar made in Sweden by the destructive distillation of resinous woods, principally that of *Pinus sylvestris*. The oil was freed from creasote-like bodies and gummy acids by repeated treatment with potassium hydrate, and then submitted to repeated fractioning. In this way there was isolated a terpene boiling at 156·5°–157·5°, and having the properties of australene, and another boiling at 173°–175° having the odor of fresh pine wood, and not identifiable with any other terpene. This the author calls sylvestrene. These two terpenes constitute 80 per cent of the oil. Sylvestrene has a specific gravity of 0·8612 at 16°, is dextrorotatory, rotating +19·5° in sodium light, and forms mono- and di-hydrochlorates, the latter of which recrystallized from alcohol yields broad flat brilliant needles fusing at 72°–73°. Heated in sealed tubes with potassium hydrate, sylvestrene yields an oil having a strong pelargonium odor.—*Ber. Berl. Chem. Ges.*, x, 1202, July, 1877.

G. F. B.

4. *On the Amylene from Amyl Iodide.*—Eltekoff has investigated the action of alcoholic potash upon the amylene dibromide obtained from amyl iodide, and concludes that this amylene is really a mixture of two isomeric bodies, isopropylethylene

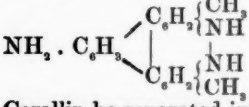
$\begin{matrix}CH[CH(CH_3)_2]\\ |\\ CH_2\end{matrix}$ whose bromine derivative gives isopropylacetylene by the action of alcoholic potash; and methylethylethylene $\begin{matrix}CH[CH_2(C_2H_5)]\\ |\\ CH_2\end{matrix}$ which does not yield valerylene under these circumstances, but is transformed into valeric ether. Isopropylacetylene boils at 35°, forms a crystalline addition product with silver nitrate $AgC{\equiv}C-CH\begin{cases}CH_3\\ CH_3\end{cases}$, which is decomposed by iodine, yielding $IC{\equiv}C-CH\begin{cases}CH_3\\ CH_3\end{cases}$, moniodisopropylacetylene. — *Bull. Soc. Ch.*, II, xxviii, Aug., 1877. G. F. B.

5. *On the Constitution of unsaturated Dibasic Acids.*—At the close of a series of researches upon certain unsaturated dibasic acids made in his laboratory, FITTIG sums up the results and discusses their bearing upon the constitution of the acids in question; i. e., fumaric and maleic acids in one group, and itaconic, citraconic and mesaconic acids in another. The facts are (1) the two former unite directly with hydrogen to yield succinic acid $\begin{matrix}CH_2.COOH\\ |\\ CH_2.COOH\end{matrix}$, as the three latter by the same treatment yield the same pyrotartaric acid, $\begin{matrix}CH_3\\ |\\ CH.COOH\\ |\\ CH_2.COOH\end{matrix}$; (2) the former acids by union with bromine give two different dibromosuccinic acids (both of which, however, are substitution products of ethylene-succinic acid), as the latter give in the same way three different dibromopyrotartaric acids (which must equally be regarded as substitution products of common pyrotartaric acid); (3) the former acids by union with hydrogen bromide yield the same bromosuccinic acid, the latter the same bromopyrotartaric acid, except itaconic acid, which yields an isomer; (4) while mono- or di-brom-citraconic and mesaconic acids lose with great ease on boiling with water or bases a molecule of carbon dioxide, becoming methacrylic or bromomethacrylic acids, probably identical, and easily reduced to isobutyric acid, the corresponding derivatives of itaconic acid are more permanent and yield no carbon dioxide when thus treated; (5) while fumarates and maleates yield on electrolysis the same acetylene, and citraconic and mesaconic acids the same allylene, itaconic acid gives a hydrocarbon not precipitating silver solutions. There is no constitutional formula which will satisfy all these conditions if the position be maintained that in unsaturated compounds the carbon atoms are *always* united by several bonds. Hence the facts compel the adoption of the view advanced by Kekulé, that beside these, there are other bodies, such as carbonous oxide for example, in which there are single carbon atoms whose attractions are not completely balanced. Rejecting also as unproved the existence in a compound of carbon atoms three of whose units are

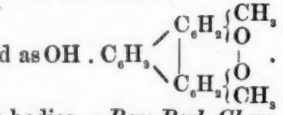
balanced while the fourth is free, the author gives for maleic acid the formula $\begin{matrix}CH_2COOH\\|\\=C.COOH\end{matrix}$ and for fumaric acid $\begin{matrix}CH.COOH\\||\\CH.COOH\end{matrix}$. For itaconic acid he gives $\begin{matrix}=CH\\|\\CH.COOH\\|\\CH_2.COOH\end{matrix}$, or $\begin{matrix}CH_2\\||\\C.COOH\\|\\CH_2.COOH\end{matrix}$, for citraconic acid $\begin{matrix}CH_3\\|\\CH.COOH\\|\\=C.COOH\end{matrix}$ and for mesaconic acid $\begin{matrix}CH_3\\|\\C.COOH\\||\\CH.COOH\end{matrix}$. Hence the isobrommaleic acid of Kekulé is properly bromfumaric acid, and the dibrommaleic acid of Bourgoin, dibromfumaric acid. Of the two itaconic acid formulas, Fittig prefers the first.—*Liebig Ann.*, clxxxviii, 95, July, 1877. G. F. B.

6. *On a Phenol of Phenanthrene, Phenanthrol.*—Rehs has examined, under Graebe's direction, the product obtained by fusing phenanthrenemonosulphonic acid with potassium hydrate. After solution in water, the phenanthrol was separated in oily drops by the addition of sulphuric acid, which solidified on cooling. After boiling with ammonium carbonate, and recrystallization from a mixture of petroleum naphtha and benzene, it was obtained in beautiful blue-fluorescing plates, fusing at 112°, and giving on analysis the formula $C_{14}H_9(OH)$. It forms well crystallized compounds with alkalies, and ethers with acid oxides.—*Ber. Berl. Chem. Ges.*, x, 1252, July, 1877. G. F. B.

7. *Formation of Rosolic acid from Cresol and Phenol.*—The discovery of Caro and Wanklyn that by de-nitrogenizing rosaniline rosolic acid could be formed, and of Dale and Schlorlemmer, that aurin (rosolic acid) could be converted into rosaniline, led Zulkowsky to attempt the production of rosolic acid from cresol and phenol as rosaniline is produced from toluidine and aniline. A mixture of two molecules cresol, one phenol and three of sulphuric acid heated with arsenic acid to 120° C. became dark brown and thick and yielded to water a gummy body with a greenish metallic luster, having all the properties of rosolic acid. It is not produced with phenol alone. The author represents rosaniline as



and rosolic acid as



Corallin he separated into five different bodies.—*Ber. Berl. Chem. Ges.*, x, 1201, July, 1877. G. F. B.

8. *A new Coloring matter.*—Hofmann has examined a new brilliant red coloring matter, obtained from Martius. He found it to be the sodium salt of an organic acid, which was separated by concentrated hydrochloric acid. Fine red needles were obtained, easily soluble in alcohol, less so in water, having the formula $C_{16}H_{12}N_2SO_4$, and being monobasic. No doubt, therefore, that

this body was analogous to chrysoidin, and that it could be formed by diazobenzol and naphtolsulphonic acid, by azosulphanilic acid with a naphtol, by azonaphtylaminsulphonic acid and phenol, and by diazonapthalene and a phenolsulphonic acid. Using the first method, and mixing sodium α naphtolsulphonate with aniline nitrate and potassium nitrite, the new color was obtained.—*Ber. Berl. Chem. Ges.*, x, 1378, July, 1877. G. F. B.

9. *Examination of a Nickel magnet.*—H. WILD. (Abstract from the original memoir). The author has submitted to examination a nickel magnet presented to Kotschubey, President of the Russian Technological Society, by Jos. Wharton of Philadelphia. It had the form of a flat bar, 2 mm. thick, 9.5 mm. broad, and 155 mm. long, pointed at the ends, and had at its center an agate cap for supporting it on a pivot. Its weight was 25 grams. Its magnetic moment was determined by comparison with a bar of steel of about the same dimensions, and found to be per gram 112,000 units, the steel giving 245,000. After remagnetizing, the nickel gave 188,000, the steel 368,000. With wolfram steel, the moment went up to 594,000 in one instance. The nickel was analyzed by Butlerow and found to contain only one-third of one per cent of iron, with traces of cobalt. The effect of temperature and of time upon the magnetism of nickel was also noted. The following are the conclusions of the memoir: 1st. Pure nickel, unlike pure soft iron, may acquire a considerable amount of permanent magnetism; but the amount of this magnetism, as a maximum, is only from one-half to one-third of that which hardened steel can receive. 2d. The magnetism remaining in the nickel after the magnetizing force ceases, is less permanent than in well hardened steel; the slow loss of magnetism in the course of time, as well as that occasioned by heating and cooling, is proportionally greater than in hardened steel, even when like the steel, it is brought by repeated warming and cooling into a certain condition of permanence. 3d. The temperature-coefficient of a nickel magnet in this condition, is a little greater than that of well hardened steel. 4th. The temporary magnetism which pure nickel assumes is about double that of its permanent magnetic moment, about half of the temporary magnetism which hardened steel can acquire and one-fourth of that capable of being developed in soft iron.—*Bull. Ac. St. Pet.*, xxiv, 1, May, 1877.

10. *Spectroscope with a Fluorescent Eye-piece.*—M. J. L. SORET has published a detailed description of improvements which he has made in the application of the well known properties of fluorescent substances to the observation of the ultra violet portions of the spectrum. He places a screen of the fluorescent material at the focus of the object-glass of the spectroscope, and views the spectrum projected on this screen with an eye-piece placed obliquely, so that the diaphragms and blackened walls of the tube may extinguish the direct rays. As a screen he uses either a small plate of uranium glass or a cell fitted with an aqueous solution of esculine; and the spectroscope is best con-

structed with lenses of quartz and prisms of Iceland spar. With lenses of glass and prisms of flint the spectrum lines could not be distinguished beyond N, but with the spectroscope whose construction he describes in detail the principal lines could be distinguished as far as T. With a more portable spectroscope of similar construction M. Soret has made observations in the Alps at an altitude of 3180 meters, and draws from them the conclusions, that although the ultra violet spectrum is more brilliant at high elevations than on the plains it has no greater extent. In the observations referred to, he could not distinguish rays more refrangible than T. Whence he infers that it is the atmosphere of the sun, and not that of the earth which absorbs the most refrangible rays of the spectrum. The diminution in brilliancy of the more refrangible portion of the spectrum caused by the atmosphere he refers not to the selective absorption of its aeriform constituents, but to the effect of the floating liquid or solid particles, which when more abundant produce a distinct haze or collect in clouds. The general absorption of light due to this last cause affects all the rays of the spectrum, but to a greater extent in proportion as the rays are the more refrangible.—*Ann. Chim. et de Phys.*, V, xi, 72. J. P. C., JR.

11. *Sun's Heat.*—M. A. CROVA has published a very extended paper on the calorific intensity of the solar radiation and its absorption by the atmosphere of the earth. In this paper the author discusses very exhaustively methods of observation and gives the results of a large number of measurements which are of great interest, but can not be described in a short abstract.—*Ann. Chim. et de Phys.*, V, xi, 433. J. P. C., JR.

12. *Changes in the Spectra of Gases caused by increasing tension.*—In the spectrum of a gas rendered luminous by an electric spark M. Wullner distinguishes two classes of effects as caused by an increasing tension. In the case of hydrogen only, the bands themselves broaden into a continuous spectrum. With other gases a continuous spectrum appears between the bands which remain meanwhile as definite as at first. In the case of compounds of carbon and markedly in the case of carbonic dioxide the brilliancy of the continuous spectrum soon becomes so great that the bands disappear, but with nitrogen and with air they can be distinguished until the pressure becomes much more considerable. This restatement of the results of previous observations is occasioned by a communication of M. Cazin who refers the continuous spectrum in such cases to the solid particles transported and rendered luminous during the electric discharge.—*Ann. Chim. et de Phys.*, V, xii, 143. J. P. C., JR.

13. "*The Influence of Light in Chemical Changes and chiefly in Oxidation*," is the subject of a recent paper by M. P. CHASTAING. The author distinguishes as a definite effect of the sun's rays the determining of the oxidation of inorganic metallic compounds, an influence which he locates in a different part of the solar spectrum from the well-known reducing action. He deduces this conclusion chiefly from the observation that the oxidation of

such substances as ferrous sulphate, alkaline solution of arsenious acid, and aqueous solutions of hydric sulphide or alkaline sulphides proceeds more rapidly in the light than in the dark, and he endeavors to estimate the action of the light by the difference in the rapidity of the process in the two cases under otherwise like conditions. He concludes that the chemical action of the solar spectrum on metallic compounds both binaries and salts while reducing at the more refrangible end is oxidizing at the less refrangible end. The general reducing action of white light he refers to the circumstance that in the rays as a whole the reducing action is the more powerful of the two. M. Chastaing finds that the green rays still exert a reducing action and he locates between the rays D and E a neutral point of the spectrum, at which chemical action takes place as in darkness. It appears however that the action exerted on organic compounds by the light is quite different from that just indicated. Its influence on such bodies is always oxidizing and this effect continually increases as we pass from the red to the violet end of the spectrum with some variation from this law in the green rays. For numerous details and subordinate conclusions we must refer to the original paper which is quite long but full of interest. We must add that results of our own do not accord, at least *apparently*, with those of M. Chastaing. We have recently discovered in the oxidation of a solution of antimonious iodide under the combined action of the air and light a direct effect of oxidation caused by the sun's rays, and this effect is produced chiefly, if not wholly, by the more refrangible rays.—*Ann. Chim. et de Phys.*, V, xi, 145. J. P. C., JR.

14. *Magnetic rotatory Polarization.*—M. HENRI BECQUEREL has very recently published the results of an important investigation on "Magnetic rotatory Polarization," which is especially interesting as supplementing the researches of his distinguished father on the same subject. His memoir is quite long and the results cannot be stated in a few words. The most important general conclusions are the following:—

(1.) That the positive rotation of the plane of polarization of a ray of light having a definite wave-length, in passing through the unit of thickness of a diamagnetic material under the influence of magnetism, is sensibly proportional to $n^2(n^2-1)$, a function of the index of refraction, and to a factor depending on the magnetism and on the diamagnetism of the body, this factor becoming the greater in proportion as the substances are more diamagnetic. (2.) That with substances chemically allied or containing the same radical the quotient of the magnetic rotation, and the corresponding value of $n^2(n^2-1)$, varies very slightly. (3.) That the chemical nature of the substance exerts an important influence on the phenomenon, and that the several constituents of a compound may produce an independent effect. (4.) That when in solution the specific effect of the molecules of diamagnetic bodies is not influenced by the concentration of the solution, while that of the molecules of magnetic bodies may be greatly affected by the

closer proximity, which such a concentration would cause, (5.) That when the substances are very diamagnetic the dispersion of the rays caused by the magnetic rotation is sensibly proportional to $\frac{n^2(n^2-1)}{\lambda^2}$ in which expression λ is the wave length and n the index of refraction. For various qualifications and details we must refer to the original paper, and also for a discussion of the theory advanced by M. Becquerel père, which refers the differences between magnetic and diamagnetic effects to the relative strength of the magnetic energy of the bodies experimented on and that of the medium by which they are surrounded. —*Ann. Chim. et de Phys.*, V, xiii, 5. J. P. C., JR.

15. *Rose-colored Sulphide of Manganese.*—The conditions of the transformation of the rose-colored sulphide of manganese obtained by precipitation into the green semi-crystalline modification of the same compound has been studied by MM. Ph. de Clermont et H. Guiot who come to the conclusion that the two substances are different states of hydration of the same body.—*Ann. Chim. et de Phys.*, V, xii, 111.

16. *Analysis of Alkaline Sulphides and Sulpho-carbonates.*—M.M. DELACHANAL et MERMET have described a new method for the complete chemical analysis of alkaline sulphides and sulpho-carbonates based on the application of hypobromite of potassium as an oxidizing agent. The method offers certain marked advantages and the values obtained indicate that it yields accurate results.—*Ann. Chim. et de Phys.*, V, xii, 88.

17. *Separation of Potassium from Sodium.*—SCHLOESING has improved and simplified the process proposed by Serullas for separating potassium from sodium based on the circumstance that potassic prochlorate is insoluble in alcohol and that of the radicals most frequently occurring in analytical processes potassium is the only one whose prochlorate does not dissolve in this solvent. He uses for the purpose pure perchloric acid, and gives simple methods for preparing this reagent in the required quantity. Perchloric acid in excess readily replaces both nitric and hydrochloric acid, forming perchlorates of the bases present. Potassic perchlorate is then easily separated and washed with alcohol of forty degrees Baumè. In this process the potassium is weighed as perchlorate after the salt has been heated to 250°, while the sodium is converted into sulphate and weighed as such.—*Ann. Chim. et de Phys.*, V, xi, 561. J. P. C., JR.

18. *A volumetric method of determining the amount of Manganese in iron ores*, is described by M. GARCIA PARREÑO which will undoubtedly be found useful in many cases. The manganese in the ore is at the outset converted into Mn_3O_4 by roasting in a platinum crucible. About a gram is taken for each assay which is dissolved in thirty-five to forty cubic centimeters of hydrochloric acid. The process is conducted in a flask, and the chlorine gas conducted into a weak solution of potassic iodide, the last traces being driven over by boiling the acid. The amount of iodine

thus set free is then determined by a standard solution of hyposulphite of sodium which bleaches the solution colored by the iodine. The solution of the hyposulphite is standardized by a preliminary experiment with pure Mn_3O_4.—*Ann. Chim. et de Phys.*, V, xi, 571. J. P. C., JR.

19. *Light: A series of simple, entertaining and inexpensive experiments in the phenomena of light, for the use of students of every age;* by ALFRED M. MAYER and CHARLES BARNARD. 112 pp. 8vo. New York, 1877, (D. Appleton & Co.).—The purpose of this little volume is to present and illustrate the fundamental phenomena of light in a manner suited to the ready comprehension of the younger class of students, and to suggest means for verifying the laws of its action by actual experiment. The text, which was prepared by Mr. Barnard and revised by Professor Mayer, is written in vivacious and entertaining style, and with such clearness and accuracy of statement that the most inexperienced student cannot fail to understand it. The experiments, which were devised by Professor Mayer, are for the most part new, and have the merit of combining precision in the methods with extreme simplicity and elegance of design. Nearly all the apparatus figured can be made by the young experimenter himself, with the use of the most common and inexpensive materials, and at a very slight expense, the whole cost of the articles required being less than fifteen dollars. The aim of the authors has been to make their readers "experimenters, strict reasoners, and exact observers," and for the attainment of this end the book is admirably adapted. Its value is further enhanced by the numerous carefully drawn and well executed cuts, which add greatly to its beauty. It is to be hoped that many will avail themselves of this opportunity to become practically acquainted with the fundamental principles of Optics. A. W. W.

20. *A Manual of Inorganic Chemistry;* Vol. II. *The Metals;* by T. E. THORPE, Ph.D., F.R.S., Professor of Chemistry in the Yorkshire College of Science, Leeds. New edition, 406 pp. 8vo. New York, 1877, (G. P. Putnam & Sons).—The previous edition of this work, as well as the other volumes by the same author, are well known among chemists, and their value fully appreciated. A feature of this new edition is the collection of examination questions and exercises at the end of the volume.

21. *A System of Volumetric Analysis, by Dr. Emil Fleischer. Translated with notes and additions from the second German edition;* by M. M. PATTISON MUIR, F.R.S.E. 274 pp. 8vo. London, 1877, (Macmillan & Co).—The peculiar merit of this work lies in the fact that it gives not "a complete collection of receipts" for independent processes, but a system of general methods under which the individual cases may be brought. As remarked by the translator the work attempts to divide volumetric processes into a few great groups, to explain clearly the principles underlying each, and further to illustrate by examples the application of these principles. It will be readily seen how much greater benefit the

student will derive from studying this subject, when so systematically presented. We are indebted to the translator for the introduction of the chemical nomenclature and notation of modern chemistry, for some advantageous condensation, and for the addition of more or less new matter.

II. Geology and Mineralogy.

1. *Geological and Geographical Survey of the Territories;* by F. V. Hayden, U. S. Geologist in charge. Conducted under the authority of the Secretary of the Navy. Washington.—The following are notices of the recent publications of Dr. Hayden's survey, which has been so rich in results to science and the country.

(1.) *Ninth Annual Report, being a Report of Progress for the year* 1875. 810 pp. 8vo, with numerous plates.—This volume contains the following Reports: A letter to the Secretary of the Interior, by Dr. F. V. Hayden (30 pp.); Geology of the Grand River District, by Dr. A. C. Peale (70 pp.); Geology of the Southeastern District of Colorado, by F. M. Endlich (134 pp.); Geology of the San Juan Division, by W. H. Holmes (50 pp.); Notes on the Tertiary and Cretaceous of Kansas, by B. F. Mudge (18 pp.). Also Topographical and Geographical Reports by A. D. Wilson and F. B. Rhoda, H. Gannett, G. B. Chittenden and G. R. Bechler; and Zoological Reports on the History of the American Bison, by J. A. Allen; and on the Rocky Mountain Locust and other injurious insects of the West, by A. S. Packard, Jr. We cite a few facts from some of these reports.

Dr. Peale describes first the topography of his region and then the distribution and characters of the geological formations. These formations include the Archæan, (visible only where the other rocks have been removed), the Carboniferous or Permo-Carboniferous, the Triassic ?, Jurassic ?, and Cretaceous, and also volcanic rocks. Dr. Peale observes that the formations afford evidence of a gradual subsidence of the surface in this part of the Rocky Mountains (the Grand River District), from Pre-Silurian times to at least the end of the Cretaceous, and of no mountain-making era between. "The Archæan area along the northern edge of the San Juan Mountains and south of the Gunnison River probably formed a shore-line in Cretaceous times." "The area of the Archæan Continent was probably of some considerable extent, and the area of this district was probably an extension of that farther east, where the main chain of the Rocky Mountains is now." No Silurian or Devonian beds were observed; and over a great part of the district the red beds (Triassic) rest immediately on the Archæan. The thickness of the Carboniferous in Colorado is stated to be 4,000 to 5,000 feet; and of this only 500 to 1,000 feet consist of fragmental rocks. The accounts of the other formation contain interesting sections and many important details.

Dr. Endlich describes the Sangre de Cristo range and the San Luis and the Huerfano region. The highest mountains of this part of Colorado generally consist, he states, of metamorphic rocks, among which granites and gneisses are the prevailing kinds. Some of them, however, carry sedimentary beds to their summits, as is the case with the Trinchera group, 13,000 feet above the sea-level. The absence of Silurian beds among the unaltered strata in connection with their presence farther east, leads Dr. Endlich to suggest that the metamorphic rocks—granites, gneisses, etc.—may belong to the Silurian and perhaps also the lowest Carboniferous, and he adds, this point is at least "entitled to further investigation." The Carboniferous and Cretaceous rocks are described and various sections are given. The volcanic rocks are spoken of as either trachyte, dolerite or basalt. There are six volcanic areas situated—near the eastern entrance of the Sangre de Cristo Pass; on the Lower Huerfano, constituting small tables; the Spanish Peaks; and a trachytic area near the headwaters of Rio Culebra and Costella. Besides these areas there are numerous dikes. In the chapter on the Sawatch Range, several remarkable examples of erosion are finely represented on the plates, in which beds of trachytic conglomerate are reduced to clusters of slender columns or monuments from 50 to 400 feet in height. An account of the coal beds of the Trinidad region contains results of assays of the coal. Dr. Endlich also discusses the distribution of the Ancient Glaciers of Southern Colorado, and illustrates the subject with a map.

Dr. Holmes describes the geology of the La Plata mining region, giving several well-executed views and sections, and stating many facts of interest connected with the trachytic eruptions. Professor Mudge presents stratigraphical details respecting the Tertiary and Cretaceous beds of Kansas.

The Topographical and Geographical Reports treat of the Grand River District, (including the Uncompahgre valley and plateau,) the San Juan District, the Front Range of the Rocky Mountains, and the Middle and South Parks, giving details of the courses and heights of mountains, systems of drainage, soil and vegetation, and a large amount of information of practical as well as scientific value. Mr. Bechler's Report covers observations for the three years, 1873, 1874, 1875. It contains a general discussion of the mountain systems of the Middle and South Parks, and is illustrated by many outline sketches which are very effective.

The Zoological Report by Mr. Allen, which had previously appeared, has already been noticed in this Journal. Professor Packard's Report treats of a subject of the highest importance to the country—the injurious insects of the west—and occupies 220 pages of the volume. He remarks that in the United States the loss of agricultural products from this source is probably over two hundred millions of dollars each year, and that from one-quarter to one-half of this amount might be saved by preventive measures. Many figures are added to the text illustrating the species.

(2.) *Bulletin of the Survey*, vol. iii, No. 4, pp. 118, 8vo, (739-856 of vol. iii).—This number of the Bulletin contains the following articles: The first discovered traces of fossil insects in the American Tertiaries, by S. H. SCUDDER; description of two species of Carabidæ from Scarboro Heights, by S. H. SCUDDER; Report on insects collected in the explorations of 1875, by P. R. UHLER; on *Cambarus Couesi*, a new craw-fish from Dakota, by T. H. STREETS; on a Carnivorous Dinosaur (*Lælaps trihedrodon*) from the Dakota beds of Colorado, by E. D. COPE; contribution to the Ichthyological fauna of the Green River Shales, by E. D. COPE; on the genus *Erisichthe*, by E. D. COPE.

Mr. Cope states that the fish of the Green River Shales represent families partly of fresh water and partly of brackish or salt water species. Material is needed to decide whether the Green River lake had communication with the sea.

(3.) *Monographs of North American Rodentia*, by ELLIOTT COUES, Assistant Surgeon U. S. A., and J. A. ALLEN, Assistant in the Museum of Comparative Zoology, Cambridge.—This large volume consists of a series of elaborate monographs of the several families of Rodents by Dr. Coues and Professor Allen. Those of the *Muridæ*, *Zapodidæ*, *Saccomyidæ*, *Haplodontidæ*, *Geomyidæ*. by Dr. Coues, and those of the *Leporidæ*, *Hystricidæ*, *Lagomyidæ*, *Castoroididæ*, *Castoridæ and Sciuridæ*, by Professor Allen. Specific and family distinctions, structural relations, geographical distribution past and present, divergences of varieties, and causes or conditions of variation, are among the subjects which come under discussion in this volume, and all the topics are treated with thoroughness and precision. The monograph on the Muridæ is accompanied by four plates. The volume closes with a synoptical list of the fossil Rodents of North America, by Professor Allen, and a Bibliography, by Mr. T. Gill and Dr. Coues.

(4.) *Miscellaneous Publications*, No. 7. *Ethnography and Philology of the Hidatsa Indians;* by WASHINGTON MATTHEWS, Assistant Surgeon, U. S. A. 240 pp. 8vo. Washington, 1877.—This volume, by one who has spent much time with the tribe treated of, contains a full account of the condition, habits, arts, history, etc., of the people, and also a discussion of the relations of its language, together with a grammar and vocabulary.

(5.) *Miscellaneous Publications*, No. 8. *Fur-bearing Animals. A Monograph of North American Mustelidæ;* by ELLIOTT COUES. 348 pp. 8vo, with 20 plates. Washington, 1877.—A work that is thoroughly scientific, while also in part popular in its character.

2. *Fifth Annual Report of the Geological and Natural History Survey of Minnesota, for the year* 1876, N. H. WINCHELL, State Geologist. 248 pp. 8vo. Saint Paul, 1877.—This volume contains reports on the Geology of Houston and Hennepin Counties, with colored maps of each, notes on the Trenton forests of Minnesota; a chemical report by Prof. S. F. PECKHAM; a list of the Fungi of the State, by Dr. A. E. JOHNSON; an entomological

report, treating of the locusts and other insects, by ALLEN WHITMAN.

The report on Hennepin County contains many valuable facts about the drift of the county, and also on the changes from erosion of the Falls of St. Anthony. According to the observations at the Falls from 1680 (by Hennepin) to the present time, the amount of recession is made out to be 906 feet, or, on an average, 5·15 feet per year. At this rate, it would have taken 8,202 years for its recession from Fort Snelling.

3. *The Geological Record for* 1875 *; an account of works on Geology, Mineralogy and Palæontology*, published during the year. Edited by WM. WHITAKER, B.A., F.G.S., of the Geological Survey of England. 444 pp. 8vo. London, 1877.—This second volume of the Geological Record will be welcomed by all who are interested in the progress of geological or mineralogical science. The notices are brief, but yet they are so well prepared as to give a correct idea of the contents of publications. It thus enables the student to survey the year's progress at a glance, and to gather up references to the papers or works which he may need to consult in detail.

4. *Preliminary Notice of the Discovery of a new Mineral Species;* by GIDEON E. MOORE, Ph.D. (Communicated.)—The species here briefly described occurs associated with chalcophanite in ochreous limonite, at the Passaic Zinc Mine, Sterling Hill, New Jersey, and presents the following characters:

In botrioidal coatings of columnar radiate structure, usually coated with a thin layer of chalcophanite.

H.=5 (Mohs's scale); G.=4·933. Luster metallic to submetallic. Color black. Streak brownish black. Opaque. Brittle.

Before the blowpipe: in the forceps unchanged; in the closed tube yields a little water. With fluxes reactions for manganese and zinc.

The analyses lead to the formula $\dot{Z}n$, $\dot{M}n$, $\dot{M}n$ or $\dot{Z}n\,\dot{M}n$. Whence the species is a zinc haussmanite.

From its invariable association with and close genetic relation to chalcophanite, I propose for the species the name *Hetærolite*, from ἑταῖρος, a companion.

Jersey City, Sept. 25, 1877.

5. *On some Tellurium and Vanadium Minerals;* by F. A. GENTH.—Dr. Genth's paper contains descriptions of three new species, whose characters are here given.

Coloradoite. Not crystallized, without cleavage; massive, somewhat granular; sometimes having an imperfectly columnar structure. (Smuggler Mine). Hardness about 3; specific gravity = 8·627 (calculated for the pure mineral). Color iron-black, inclining to gray with a very faint purplish hue; luster metallic; surface frequently tarnished. Fracture uneven to subconchoidal. Composition: HgTe = Tellurium 39·02, mercury 60·98 = 100; all the specimens analyzed were more or less impure, as it was impossible to separate entirely the associated minerals. Found in Colorado at the Keystone and Mountain Lion Mines, with

native tellurium and quartz; also at the Smuggler Mine, where it is often mixed with native gold, tellurium and tellurite.

Magnolite. Occurs in exceedingly fine needles, grouped in bundles or tufts, sometimes radiating. Color white; luster silky. Composition: Hg_2TeO_4. Found at the Keystone Mine, Magnolia District, Colorado; it occurs in the upper decomposed portion of the mine, with quartz, limonite and psilomelane, having been produced by the oxidation of coloradoite.

Ferrotellurite. A crystalline coating on quartz, associated with native tellurium; under the microscope it appears in very delicate tufts, sometimes radiating, or in cavities in minute prismatic crystals of a color between straw and lemon-yellow inclining to greenish-yellow. Composition probably $FeTeO_4$; the small quantity in hand did not allow of a reliable analysis. Found at the Keystone Mine, Colorado.

Dr. Genth also mentions the occurrence of *Tellurite* (tellurium dioxide, TeO_2) at the Keystone, Smuggler, and especially at the John Jay Mine, Colorado. It is found in minute white, yellowish-white and yellow crystals, mostly prismatic, isolated or aggregated into bundles. Cleavage eminent in one direction, luster on this face adamantine, elsewhere vitreous inclining to resinous. The same compound was observed by Petz with native tellurium at Transylvania. Native tellurium has been found, according to Dr. Genth, at the Keystone, Mountain Lion and Dun Raven Mines in Magnolia District, Boulder Co., Colorado, also at the Smuggler Mine in Ballerat District, Boulder Co.; hessite, (containing only ·1 per cent gold) has been found at the Kearsarge Mine, Dry Cañon, Utah; calaverite occurs at the Keystone and Mountain Lion Mines, Colorado.

Roscoelite is shown to contain not V_2O_5 (as assumed by Prof. Roscoe), but probably V_2O_3; a related "green mineral" has been found in an impure state in the gangue rock of the mines in Magnolia District, Colorado; it contains, however, more aluminum and less vanadium. An analysis of the Siberian volborthite is given, and its relation shown to the species psittacinite. E. S. D.

6. *Mineralogische Mittheilungen* von G. VOM RATH.—The recent mineralogical memoirs of the eminent crystallographer, Prof. vom Rath of Bonn, contain descriptions of crystals of gold, of a remarkable twin of smaltite, of rutile in the form of hematite from Switzerland, and on compound rutile crystals from Arkansas; the explanation of the obscure crystallization of the plates, and thread-like forms of gold, is an especially valuable contribution, and is elucidated by a considerable number of figures. E. S. D.

7. *Elemente der Mineralogie* von CARL FRIEDRICH NAUMANN. *Zehnte gänzlich neubearbeitete Auflage* von Dr. FERDINAND ZIRKEL. 714 pp. 8vo. Leipzig, 1877, (Wilhelm Engelmann).—The Mineralogy of Naumann has long been the standard work in Germany. The first edition was published in 1846; the ninth edition bears the date October 18, 1873, only a few weeks before the close of the author's long and active career. Fortunately this, his most

important work, did not end with his death, but its continuation has been undertaken by one well fitted to perform the task. The present edition, while including much new matter, retains the form and arrangement of those which have preceded except in one most important particular: the awkward and antiquated system of classification of mineral species employed by Naumann has been replaced by the now generally accepted method based upon their chemical composition. This will be seen to be a most important change for the better, increasing much the value of the work.

E. S. D.

III. Botany and Zoology.

1. *Occurrence of another gigantic Cephalopod on the coast of Newfoundland;* by A. E. Verrill.—A nearly perfect specimen of a large squid, was found cast ashore after a severe gale, at Catalina, Trinity Bay, Newfoundland, Sept. 24. It was living when found. It was exhibited for two or three days at St. Johns, and subsequently was carried in brine to New York, where it was purchased by Reiche & Bro. for the New York Aquarium, where I have had an opportunity to examine it.* Although somewhat mutilated, and not in a very good state of preservation when received, it is of great interest, being, without doubt, the largest and best specimen ever preserved. It proves to be *Architeuthis princeps*, formerly described by me, from the jaws alone, in this Journal.† The jaws agree well in form and color with the large pair there figured, and are fully equal to them in size, being apparently larger in proportion to the body than in *A. monachus*, so that my estimate of the probable size of the body of the former specimen was much too great. The Catalina specimen, when fresh,‡ was 9·5 feet from tip of tail to base of arms; circumference of body 7 feet, length of tentacular arms 30 feet; length of longest sessile arms (ventral ones) 11 feet; circumference at base 17 inches. Length of upper mandible 5·25 inches; diameter of large suckers 1 inch; diameter of eye-sockets 8 inches. The eyes were destroyed by the captors. It agrees in general appearance with *A. monachus*, but the caudal fin is broader and less acutely pointed; it was two feet and nine inches broad when fresh, and broadly sagittate in form. The rims of the large suckers are white, with very acutely serrate margins, and the small smooth-rimmed suckers, with their accompanying tubercles, are distantly scattered along most of the inner face of the tentacular arms, the last ones noticed being nineteen feet from the tips. The sessile arms present considerable disparity in length and size, the dorsal ones being somewhat shorter and smaller than the others; the serrations are smaller on the inner edge than on the outer of the

* When examined by me it was loose in a tank of alcohol. I learn that it has since been "prepared" for exhibition by a taxidermist, who has inserted two large, round, red eyes close together on the top of the head!

† Vol. ix, p. 181. Plate V. figs. 14, 15. March, 1875.

‡ Measurements of the freshly caught specimen were made by Rev. M. Harvey, at St. Johns, and communicated to me.

suckers. A more detailed description is deferred to a succeeding number, together with a description of another specimen.

2. *The Antelope and Deer of America;* by JOHN DEAN EATON. 8vo, 426 pp., numerous cuts. New York, (Hurd & Houghton.) 1877.—This is an excellent treatise on the prong-horn antelope and the various species of deer, moose and elk, of which eight species are recognized. The descriptions of the species are detailed, and a large part of the book is devoted to their habits, domestication, hybridity, aliment, diseases, the chase, comparisons with congeners, and other kindred subjects. The illustrations are well executed and characteristic. v.

3. *Life Histories of the Birds of Eastern Pennsylvania;* by THOMAS G. GENTRY. Vol. ii, 8vo, 399 pp. Philadelphia. Published by the author, 1877.—The second volume of this work, which has just reached us, is, like the first, replete with details in respect to the habits of birds, and more especially as to their migrations, the time occupied in building nests and incubating, and the nature of food at different seasons of the year. In this consists its chief scientific value. The author has evidently spent a great amount of time and labor in making and recording observations of this kind. The volumes include all the families above the waders, and the author proposes to complete the work in another volume. v.

4. *Zoologische Wandtafeln;* by Dr. R. LEUCKART and Dr. H. NITSCHE. Cassel: Theodor Fischer.—We have received three examples (Protozoa, Cœlenterata, Arthropoda) of these lithographic zoological diagrams. They are admirably executed. The figures are large and clearly drawn, and printed in strong colors, so that they are excellently adapted for class rooms of large size. They will thus supply a want that has long been felt by teachers of zoology. The figures have been well selected from the best works, including very recent memoirs. Each diagram is printed in sections, on four sheets, and can easily be mounted on cloth backs. We heartily commend this series to all teachers who are in want of illustrative zoological diagrams. v.

5. *Bulletin of the U. S. National Museum.* Department of the Interior.—Numbers 7, 8 and 9 of this Bulletin have recently been issued. No. 7 contains contributions to the Natural History of the Hawaiian and Fanning Islands and Lower California, by T. H. STREETS, M.D., 169 pp. 8vo, 1877; No. 8, Index to the Names which have been applied to the subdivisions of the Class Brachiopoda, by W. H. DALL, 88 pp. 8vo, 1877; No. 9, contributions to North American Ichthyology; No. 1, by DAVID S. JORDAN, 54 pp. 8vo, 1877.

6. *Notes on some Common Diseases [of plants] caused by Fungi;* by W. G. FARLOW. Bulletin of the Bussey Institution, vol. ii, part 2, 1877.—Leaving to another department of the Journal to notice the interesting papers on the composition of pumpkins and squashes, the analyses of certain seeds occasionally used for human food, and two or three other papers by Prof. Storer which this new number

of the Bussey Bulletin contains, we call attention here only to Prof. Farlow's short article, which refers to some of the various questions and problems he has had to deal with during the past year. They mainly relate to the Black Knot of Plum trees, which was the subject of a former paper; to the American Grape-vine mildew (*Peronospora viticola*), and a disease caused by *Uncinula spiralis* the conidial form of which is practically undistinguishable from the notorious *Oidium Tuckeri;* to the *Fumago* of Orange and Lemon trees, in which it appears that the mischief produced is owing to a wooly plant-louse, upon the excretions of which, or the exudations of the leaf caused by the punctures, the fungus is thought to live; and, finally, there are some notes supplementary to Prof. Farlow's memoir on the Onion-smut. It seems that this *Urocystis Cepulæ* of Frost is not peculiar to the United States, but is to all appearance the same as *U. magica*, found on an Italian *Allium* in Italy. "A careful examination of the wild species of Onion growing in our own country should be made by fungologists, for it seems highly probable that the fungus which does so much injury to cultivated onions will also be found on the wild species." It is well that we have in this country an institution which furthers investigations of this sort, and intends to educate a generation of teachers capable of undertaking them. A. G.

7. *Flora Brasiliensis.*—The 70th fascicle, a large one, with 70 plates, is filled with Bentham's elaboration of the *Mimoseæ*, and concludes the sixteenth volume. The 71st contains the small orders, *Ochnaceæ*, *Anacardiaceæ*, *Sabiaceæ*, and *Rhizophoraceæ*, by Dr. Engler. As to *Ochnaceæ*, the author confirms Planchon's idea, announced in 1862 but not anywhere acted upon, that this order embraces *Sauvagesia;* and he insists that it is allied to *Dilleniaceæ* and not to *Rutaceæ*. For the large genus of the order, Engler, following Baillon, replaces Schreber's long received name of *Gomphia* by *Ouratea* of Aublet, and he appears to have seen and identified Aublet's original specimens. In *Anacardiaceæ* the genus *Lithrea* of Miers is reinstated. Brazil has but one species of the order *Sabiaceæ*, and only one Mangrove. Fascicle 72, which is rather large, continues the Grasses and includes the tribe *Paniceæ*. The editor, Dr. Dœll, describes 156 Brazilian species of *Panicum* (keeping *Helopus* distinct) and 105 of *Paspalum.* A. G.

8. *Botany of British Columbia and Northern Rocky Mountains.*—In the *Report of Progress* of the *Geological Survey of Canada for* 1875–76, issued in 1877, we find an interesting narrative, by Professor John Macoun, of a botanical exploration from Victoria to the Peace and Athabasca Rivers east of the Rocky Mountains, and thence to Canada, to which is appended a full Catalogue of the Plants collected, or known to Mr. Macoun to occur on this range, with a careful indication of their geographical distribution across the continent. A very useful and important paper. A. G.

9. *Sketch of the Vegetation of the Nicobar Islands; Enumeration of Burmese Palms; Contributions toward a knowledge of the*

Burmese Flora, etc.; by S. KURZ.—These are the titles of some of the principal papers recently contributed by Dr. Kurz to the Journal of the Asiatic Society of Bengal, which we have received, and which seem not to be as well known as they deserve to be. Besides critical systematic work, there are interesting observations upon the kinds and characteristics of tropical forests, etc. The subjoined note may be a caution to those who collect native names. "*Petal* occurs as a name for several different plants in Jelinck's journal. I fear it is meant for '*bétúl*' ('*just so*,' '*right so*'), a very usual reply of a Malay to a question regarding the pronunciation of a word." A. G.

10. *Arboretum Segrezianum* .... par ALPH. LAVALLÉE.—This handsome octavo volume, as its full title declares, is an enumeration of the trees and shrubs cultivated at Segrez (Seine and Oise), including their synonymy and their origin, with references to the works in which they are figured. It is published by Baillière, is edited with much care (yet not to the avoidance of sundry mistakes and misprints in other than French names, etc.), and is beautifully printed. It represents a great amount of conscientious work while the author was forming the Arboretum which now adorns his paternal estate, and which bids fair to be one of the very best in France, although as yet only twenty years old. The catalogue is prefaced by some notice of its formation, and of the origin and condition of several of the older French collections. Among the difficulties encountered, that of nomenclature was foremost and greatest, the same tree coming to him under various different names, and different trees under the same name, sometimes through traditional errors or oversights of the nurserymen, sometimes through less innocent practices of "*quelques horticulteurs*," which our author is constrained to denounce. In consequence he was obliged to study up the nomenclature and arrange the synonymy for himself throughout, with the best aid to be had from the *Jardin des Plantes* and elsewhere. Hence the *raison d'être* of this volume, and its value to all who have similar collections to make, or to care for. A. G.

11. *Systema Iridacearum*; by J. G. BAKER.—This begins in the 90th number of the Journal of the Linnean Society, and is continued in the following. When concluded, we may give an abstract of the portions which relate to North American botany. Mr. Baker's work upon the monocotyledonous orders has been useful and timely, and the *Iridaceæ* particularly need revision, having been almost untouched by all later systematists, except by Dr. Platt, whose synopsis in the Linnea is far from complete, being founded mainly upon the materials in the Berlin herbarium, and whose views are not always to be adopted. A. G.

12. *Native "Artichokes."*—Upon reading the article upon *Helianthus tuberosus*, contributed to this Journal (in May last) by Messrs. Trumbull and Gray, the well-known Canadian botanist and explorer, Mr. John Macom, wrote as follows:

"It is a fact that a species of *Helianthus* which I took to be *H.*

tuberosus, grows in abundance in the valley of the Kaministiknia, on the right bank of the river, above Point Memon. This river discharges into Thunder Bay, Lake Superior, and is quite easy of access from the United States. I saw the plant growing in abundance on the alluvial flats on the 12th July, 1869, and found the tubers of a large size at that time. Whether my plant is the true tuberosus or not, it is certainly the parent of the Indian tuber. Where I got it was on the old (high) road to the northwest. It would be worth while to have one of the American tourists get a few plants late in August. I have no doubt but I have hit upon the exact locality from which the French took the tubers, and it only remains to identify my plant with *H. doronicoides*."

It is well to know of this station; but the Hurons of Sagard's narrative doubtless dwelt much farther east.

Dr. C. C. Parry has directed our attention to his list of plants of Wisconsin and Minnesota, published in Owen's Geographical Survey of Wisconsin, Iowa and Minnesota, in which, on page 614, is the entry: "*Helianthus tuberosus* L., Common Artichoke, river banks, St. Peter and St. Croix, certainly native, and a well-known article of diet among the Indians, called by the Chippewas Ushke-baug." An original specimen was kindly supplied by Dr. Parry, of which at this moment we can only say that it does not belong to *Helianthus tuberosus*. Thus there appears to be a second edible tuberiferous *Helianthus*, of which a further knowledge is a desideratum.

In regard to the other sort of root mentioned by Sagard as resembling parsnips, "which they call *Sondhratates*, and which are much better," Dr. Macom is confident that not *Sium lineare* but *Aralia racemosa* is meant: for the older inhabitants of that part of Canada affirm that the root of this *Aralia* was a favorite food of the Indians, and that they taught its use to the first settlers. In flavor this root (commonly called "spikenard" and "spignet") might well be said to resemble parsnips. A. G.

13. *Necrological.*—There have died during the past summer two European botanists of note, namely, HENRY A. WEDDELL and PHILIP PARLATORE; notices of whom will be given in the obituary record of the year. A. G.

IV. ASTRONOMY.

1. *Discovery of a New Planet;* by C. H. F. PETERS. (From a letter to the editors, dated Litchfield Observatory of Hamilton College, Clinton, N. Y., Oct. 15, 1877.)—I take pleasure in forwarding an observation of a new planet found last night, showing the brightness of a star of 10·5 magnitude:

Oct. 14. 12h 39m 51s H. C. m. t. $\alpha(175) = 1^h\,6^m\,4.73^s$. $\delta(175) = +8°\,6'\,37.4''$,

from 18 comparisons with Schj. 397. The daily motion of the planet is about 36^s in right ascension, and between 13′ and 14′ in declination toward the south. You are perhaps already aware, that the planet, of which the last number of the Journal contains

a valuable series of observations with the number (174), is identical with the planet (141) *Lumen*; so that what is called there (175), receives the former, and the present planet the latter number.

2. *Comets in* 1877.—The number of comets for the present year already amounts to six. 1. Discovered by Borrelly, Feb. 8th. 2. Discovered by Winnecke, April 5th. 3. Discovered by Swift, April 11th. 4. Discovered by Coggia, Sept. 13th. 5. Discovered by Tempel, Oct. 2. To these is to be added d'Arrest's comet of short period.

3. *Observations and Orbit of Tempel's Comet.*—Comet *b*, 1877, discovered by Tempel October 2d, was first seen at the Observatory of the Sheffield Scientific School October 5th. From measurements made on the 5th, 7th and 9th, the following provisional orbit has been computed. The comet is receding from both the earth and sun, and will soon disappear. From places computed for August 1st and September 1st it appears that the comet must have been in reach of the telescope for a time after evening twilight as early as July, and has been ever since that time both favorably situated for observation and at least as bright as when discovered. It cannot have approached us at any time nearer than about ·8 of the earth's radius vector. These elements show no marked resemblance to those of any previously calculated orbit. The observations were made and orbit computed by Mr. W. Beebe and Mr. H. A. Hazen.

New Haven m. t.	Comet's α (m. eq. 1877·0).	Comet's δ.
	h m s	
Oct. 5, 10 30·7	23 39 12·7	−13° 50′ 9″
7, 9 48·3	32 31·0	15 40 47
9, 9 25·2	26 29·1	17 20 58
11, 7 45.4	21 7·7	18 48 53

T=1877, June 26·800 Wash. m. t.
π = 80° 43′·2
Ω = 184 17 ·9 } m. eq. 1877·0
i = 115 54 ·0
log. q = ·031956

	C.—O.	
	$\Delta\alpha$	$\Delta\delta$
Oct. 7,	−1ˢ	+ 2″
11,	−·9	+38

V. Miscellaneous Scientific Intelligence.

1. *Proceedings of the Davenport Academy of Natural Sciences.* Vol. ii, Part 1. Jan., 1876 to June, 1877. 148 pp. 8vo.—The Davenport Academy publications are especially rich in papers on American Archæology. The number of the Proceedings before us contains several papers of this character by the following authors: W. H. Pratt, Rev. J. Gass, R. J. Farquharson, M.D., Rev. S. D. Peet, C. T. Lindley and Julia J. Wirt.

Mr. Gass announces the discovery of three engraved tablets in an Indian mound, which he calls "Mound No. 3 of the Cook's Farm Group;" and these are particularly described by Mr. Farquharson in a paper illustrated by excellent photographs of the tablets. One represents a calendar, another a sacrificial or cremation scene, and the third a hunting scene. In the last, thirty indi-

viduals are represented: of man, 8; bison, 4; deer, 4; birds, 3; hares, 3; big-horn or Rocky Mountain goat, 1; fishes, 1; prairie wolf, 1; non-descript animals, 3. One of the last three it is suggested may be the Mastodon, and hence, and in view of other published announcements, the cotemporaneity of Man and the Mastodon is deemed probable. The number contains also a few zoological papers by J. D. Putnam.

2. *U. S. Geographical and Geological Survey of the Rocky Mountain Region.* J. W. POWELL, Geologist in charge. Department of the Interior.—This survey, under the Interior Department, has recently issued volume I of *Contributions to North American Ethnology*, a quarto volume of 362 pages, with many illustrations. Part I contains a Report on the tribes of the extreme Northwest; by W. H. DALL; Part II, on the tribes of Western Washington and Northwestern Oregon, with a map, by GEORGE GIBBS, including, in an appendix of 122 pages, comparative vocabularies, and a Niskwalli-English and English-Niskwalli Dictionary.

3. *Burial Customs of North American Indians;* Mr. H. C. YARROW, of Washington, D. C., has issued a circular requesting information in aid of a memoir he is preparing, upon the "Burial Customs of the Indians of North America, both ancient and modern, and the disposal of their dead," and to this end invites attention to the following points in regard to which information is desired: Name of the tribe; locality; manner of burial, ancient and modern; funeral ceremonies; mourning observances, if any. The material obtained will be published under the auspices of Major J. W. Powell, in charge of the U. S. Geographical and Geological Survey of the Rocky Mountain Region. Communications may be addressed to Mr. Yarrow, 1747 F St., Washington, or at the Army Medical Museum, Washington, D. C. The circular contains more detailed statements.

4. *On the Science of Weighing and Measuring and Standards of Measure and Weight;* by H. W. CHISHOLM, Warden of the Standards. 192 pp. 8vo. London: 1877, (Macmillan & Co. Nature Series).—This little volume contains a very interesting account of the ancient standards of weight and measure, more particularly those of England; it also describes the methods employed in the restoration of the imperial pound and yard after their destruction by the burning of the Houses of Parliament in 1834. Another chapter is devoted to the Metric System, and one also to instruments for weighing and measuring. The numerous illustrations of the ancient standards add much to the interest of the description.

5. *How to draw a Straight Line; A Lecture on Linkages;* by A. B. KEMPE, B.A. 51 pp. 8vo. London, 1877, (Macmillan & Co. Nature Series).—A description of the ingenious systems of linkages with which it is possible to draw a straight line, to trisect an angle, and to solve other geometrical problems.

6. *The Elements of Descriptive Geometry, Shadows and Perspective, with a brief statement of trihedrals, transversals, and*

spherical axonometric and oblique projections. For colleges and Scientific Schools; by S. EDWARD WARREN, C.E. 282 pp. 8vo. New York, 1877, (John Wiley & Sons).—A valuable work for students in descriptive geometry. It is intended as a concise text-book, and is rendered more useful in this work by the addition of numerous examples in connection with the successive problems.

7. *Smithsonian Report for* 1876.—Many are the ways in which the Smithsonian Institution is promoting the progress of science in the land. One among these, of very wide influence, is the publication, in its Annual Report, of an appendix containing memoirs on scientific subjects. Among the memoirs in the Report for 1876 there are the following:

Eulogy of Guy Lussac, by M. Arago; a biographical sketch of Dom Pedro II, by A. Fialho; a paper reviewing the kinetic theories of Gravitation, by W. B. Taylor; on the Revolutions of the Crust of the Earth, by Prof. G. Pilar, of Brussels; on the Asteroids between Mars and Jupiter, by D. Kirkwood; and various Ethnological papers, relating mostly to American relics. One of the papers, that on the Latimer Collection of Antiquities (from Porto Rico), now in the Smithsonian Museum, by O. T. Mason, is illustrated by sixty figures; and another, on Mounds in Wisconsin, by M. Strong, by five figures or diagrams.

RECEIVED TOO LATE FOR FURTHER NOTICE HERE.

Palæontology of the Geological Survey of the State of New York: Illustrations of Devonian Fossils, Gasteropoda, Pteropoda, Cephalopoda, Crustacea, and Corals of the Upper Helderberg, Hamilton and Chemung Groups; by JAMES HALL. Published in advance of the Palæontology of New York, by authority of the Legislature of the State of New York, nearly 150 plates, 4to. Albany. 1877.

Twenty-eighth Annual Report of the New York State Museum of Natural History, by the Regents of the University of the State of New York (ex-officio Trustees of the Museum). Transmitted to the Legislature March 30, 1875; containing a paper by James Hall, consisting of 34 plates of fossils of the Niagara group of Central Indiana with explanations, and important papers on Trilobites, etc., by C. D. Walcott, with a Botanical Report, by C. H. Peck.

OBITUARY.

URBAN J. J. LEVERRIER, the French astronomer, died on Sunday, the 23d of September, at the age of sixty-six, having been born on the 11th of March, 1811.

JOHN G. ANTHONY, the conchologist, Professor in Harvard College, Cambridge, Mass., died on the 9th of October, aged seventy-three years. He was born in Providence, Rhode Island, May 17, 1804.

BENJAMIN HALLOWELL, author of a work on Geometrical Analysis, died at Nair Hill, Montgomery County, Maryland, in his seventy-eighth year.